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PHYSICAL THERAPY IN OPHTHALMOLOGIC PRACTICE

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I shall consider only a few phases of physical therapy and shall limit my remarks to procedures which have, or seem destined to have, a definite place in ophthalmologic practice.

PHOTOTHERAPY

Phototherapy may be considered briefly, since few recent advances have been made in this field. The indications for general phototherapy are well known, although ophthalmologists are likely to forget them. The object of this form of treatment is to produce repeated mild cutaneous reactions, with a resulting increase in the various bactericidal constituents of the blood and better utilization of calcium and vitamin D by the tissues. Such treatment is nearly always indicated in cases of phlyctenulosis when proper use of sunlight cannot be secured. With the use of a large mercury vapor or carbon arc lamp, one third of the surface of the body is irradiated at a sitting, the dose being chosen which will produce a slight erythema. Such treatments are given to other areas twice a week and repeated until from fifteen to twenty-five treatments have been given. Administration of calcium and vitamin D by mouth is a useful adjuvant to general phototherapy. In cases of any form of ocular inflammation affecting a person with poor general resistance, and especially in cases of uveitis considered to be tuberculous, general phototherapy may be of considerable value and should be employed more often. The same is true of that severe and intractable condition sclerosing keratitis.

Local phototherapy has not lived up to the expectations which were held for it fifteen years ago. A few ophthalmologists still uphold its efficacy in the treatment of severe corneal infections, such as serpent

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ulcer. Many never use it, while others employ it in a relatively small number of cases, chiefly those of superficial corneal infection. At the 1928 meeting of the American Academy of Ophthalmology and Otolaryngology, in a résumé of phototherapy, and in my "Hand-Book of Ocular Therapeutics," I [1] gave reasons for discarding the procedure in the treatment of serpent ulcer, other deep corneal infections and inflammation of the posterior segment. On account of the complete absorption of ultraviolet rays by a thin layer of opaque tissue, it seemed that its only possible effect could be expected in superficial forms of keratitis, such as dendritic or herpetic ulcer, degenerative ulcers on the surface of old scars and the ulcers of trachoma. For many years I treated all ulcers of this type with the Birch-Hirschfeld uviol lamp or with a home-made arc lamp embodying quartz lenses and a filter of Corning glass 958 A. With the former lamp, treatments of from five to eight minutes in duration were given daily, since even with such long exposures erythema is not produced. With the latter lamp, erythema is produced in about one minute; so treatments were limited to fifty seconds and given three times a week. The lesions were stained with fluorescein or a 1 per cent solution of bengal rose before such treatment. A distinct impression was obtained that the irradiation was of value in such cases, since ulcers usually healed after two or three such treatments, and occasionally after one. Other agents, however, such as iodine, were usually employed, so that healing could not with certainty be attributed to the irradiation. Also, there were a few cases in which healing did not occur with such treatment, other measures being necessary. One of these measures, roentgen therapy, will be discussed later. Experimentally, Gunderson could demonstrate no effect of ultraviolet rays on the herpes virus. Since most of these superficial ulcers heal after the use of chemical agents, and since results have apparently been obtained by roentgen therapy in cases in which the ulcers resisted phototherapy, the useful field for local phototherapy seems to be contracting further and further. It is probably not too much to say that the ophthalmologist who is familiar with the use of other agents, especially roentgen therapy in suitable cases, can dispense with local phototherapy entirely.

USE OF COLD

I should like to emphasize the tremendous value of cold when applied after certain operations, and a simple but effective way of applying it. Any one who will compare the results of alternate operations for squint with and without the application of cold as a routine measure can hardly fail to be impressed with the difference in the postoperative reactions.

1. Gifford, Sanford R.: Tr. Am. Acad. Ophth. **33**:195, 1928; Hand-Book of Ocular Therapeutics, Philadelphia, Lea & Febiger, 1937, p. 103.

Chemosis and congestion after operations for squint with the use of cold are minimal and in many cases almost entirely absent. The effect is even more striking after simple evisceration of the globe, while without the use of cold chemosis was always extreme and very persistent. In operations for ptosis, since the use of Friedenwald's procedure of protecting the cornea by the lower lid, it has become possible to use cold, and the results are well worth the trouble. The practical method of applying cold is that used in Dr. Loyal Davis' neurosurgical cases at the Passavant Hospital and is probably familiar to most physicians. Finely chopped ice is placed in a thin rubber glove, the fingers of which are tied off so that a small flexible bag is formed. This is covered by a single layer of thin gauze and applied to the closed lids, which may be covered by a single layer of sterile gauze if skin sutures have been employed. This treatment is carried out during the alternate waking hours; it is begun immediately after operation and continued for three or four days, as a rule. I have never seen any evidence of delayed healing or of damage to the corneal nutrition resulting from such use of cold. The effect on postoperative pain, as well as on chemosis, is often gratifying.

THERMAL THERAPY

Infra-Red Lamps.—Coulter has given experimental evidence indicating that greater heat may be produced in the tissues with infra-red lamps than with heating pads, and almost the same superiority probably holds when the heat of infra-red lamps is compared with that of moist hot packs. There are also practical reasons for preferring infra-red lamps for routine use in the hospital or the home. Such heat is clean and may be employed after operations without danger of infection. It avoids direct contact with the lids, which is of advantage in cases of recent operation or wound. The use of lamps lessens the amount of nursing care required, as compared with moist heat, since the patient is easily taught to adjust the lamp to the limit of skin tolerance. The more expensive infra-red lamps which are usually available in hospitals may be replaced by inexpensive models for use by the patient at home.

The indications for infra-red therapy include all forms of inflammation of the eyes and adnexa except those in which danger of hemorrhage exists. Other exceptions are glaucoma and the early stages of conjunctivitis in which swelling and chemosis might be increased. In cases of acute iritis, postoperative iritis, acute cellulitis and deep infection of the lids, heat is especially important and may be used almost continuously.

Diathermy.—Heat generated by electrical energy in the tissues will be discussed only in its nonsurgical aspects. Reports on the use of

local nonsurgical long wave diathermy in the treatment of ocular diseases have been numerous, and a variety of conditions have been treated, as shown in a recent review by Nugent.[2] Coulter has compared the efficacy of long wave diathermy with that of short wave therapy. He has shown that with both methods higher temperatures can be produced in the deeper tissues of the eye and orbit than is possible with infra-red lamps. With the short wave method the higher temperatures may be reached more quickly and with less danger of burning the skin. With the glass electrodes now in use the effect may be fairly well localized. It is not known exactly what temperatures are tolerated by the normal ocular tissues without producing permanent degenerative changes. Hoffmann and Kunz [3] found that at 43.5 C. (110.3 F.) marked circulatory changes occurred in the choroid, including hemorrhages. At from 42 to 43 C. (107.6 to 109.6 F.) the retinal ganglion cells showed edema and degenerative changes. Opacities of the lens were seen only with somewhat higher temperatures after one exposure, but the effect of repeated exposures was not determined. The duration of Hoffmann and Kunz's experiment was from fifteen to twenty-five minutes, the maximal temperature being maintained for ten minutes.

It would seem unwise to raise the temperature inside the eye much above 105 F. (40.5 C.), since the danger of hemorrhage must be considered as probably greater in eyes with inflammatory conditions or disease of the blood vessels.

The difficulty in obtaining a dose which will assure this limit of temperature is at once evident. All that can be done is to imitate closely the technic with which the desirable temperature has been obtained in experimental work and that which has been employed in a large number of cases by reliable observers without causing detectable damage to the eye. Kokott [4] employed Siemen's ultratherm, which generates waves of 6 meters, the electrodes being placed in contact with the skin and 2 cm. apart. He employed the technic recommended by the manufacturers for therapeutic work. The highest temperatures were obtained in the vitreous, an increase of 4.8 degrees C. (8.6 degrees F.) occurring in ten minutes and only slightly more after fifteen minutes. This temperature would approximate 107.2 F. Heating was less in the orbit, the increase averaging 2.9 degrees C. (5.2 degrees F.) in contrast to 4.8 degrees C. in the vitreous. There was some variation in the temperatures produced in various animals. Kokott expressed the belief that exposures of ten minutes are long enough to produce a practical maximum of heating without certain dangers of longer exposures, especially that of pro-

2. Nugent, O. B.: Arch. Phys. Therapy **17**:234, 1936.
3. Hoffmann, W., and Kunz, E.: Arch. f. Ophth. **132**:155, 1934.
4. Kokott, W.: Klin. Monatsbl. f. Augenh. **97**:448, 1936.

ducing cerebral disturbances. He obtained some burns with this technic and advised that more exact dosage and localization of the current are desirable.

Puntenney and Osborn, in some work now being conducted at Northwestern University, a report of which will be published later, obtained results which agreed in most essentials with those of Kokott. With the same instrument, the glass electrodes being placed one over the eye and the other back of the neck, the temperature in the vitreous was raised within twenty minutes to from 107 to 109 F. Cooling from the highest point occurred rapidly after the current was turned off, the temperature reaching to 103 or 104 F. within twenty minutes and usually returning to normal within one hour. The body temperature was considerably higher than in Kokott's experiment, but in most animals it remained an average of 3 degrees F. lower than that of the vitreous. When the two electrodes were placed on either side of the eye such high temperatures were not obtained, the maximum being 106.7 F. and the average 103 F. Cooling also occurred much more quickly with this technic. With a ten minute exposure, almost the same temperature could be reached, but cooling was much more rapid. Careful measurement of the retinal vessels by Lambert's method revealed no actual dilatation of the larger vessels in any animal, which is in contradiction to the impression gained by many observers from their ophthalmoscopic findings. This method is accurate, certainly more so than the usual impression obtained from the ophthalmoscopic picture. It does not exclude, of course, dilatation in the capillary bed. Individual differences between animals were considerable, and it certainly cannot be stated that the same temperatures could be produced in man by approximately the same technic; so direct observation on human eyes before enucleation is desirable and is being undertaken. The temperatures here recorded, while higher than some of those with which Hoffmann and Kunz observed damage to retinal structures, were not maintained so long as in their experiments.

Of clinical reports, that of Gutsch [5] gives his experience in treating two hundred and seventy-six patients with ocular disease. He employed the same machine as Kokott did, using glass shell electrodes held from 1 to 3 cm. from the globe, with exposures beginning at from six to eight minutes and being increased to fifteen minutes in certain cases. Treatments were given two or three times a week. He saw no evidence of damage in any case. He saw no definite beneficial effect in cases of corneal disease, glaucoma or scleritis, and the effects in cases of acute iritis were doubtful. He was impressed by the benefits obtained in

5. Gutsch, N.: Ber. ü. d. Versamml. d. deutsch. ophth. Gesellsch. **51**:221, 1936.

cases of chronic iridocyclitis, especially the tuberculous form, and in cases of vascular disease of the fundus. In three cases of conglomerate tubercle of the iris and two of conglomerate tubercle of the choroid the lesions disappeared rapidly under treatment. In cases of acute orbital cellulitis and acute dacryocystitis the inflammation subsided rapidly. Wegner, in discussing Gutsch's paper, reported no results in cases of chronic uveitis and stated that he saw a retinal hemorrhage occur after treatment. Scheyhing [6] employed a similar technic and reported good results in various inflammatory conditions, but gave few details. In brief clinical reports, Carlotti [7] and Kuwahara [8] also claimed good results for the method. The report of Krause [9] is chiefly clinical but includes observations on rabbits treated for ten successive days with the usual dose. No damage to the eyes was noted. The best clinical results were obtained in infection of the lids and dacryocystitis, in which conditions resolution occurred with striking rapidity. In one case of postoperative iritis with hypopyon the lesions cleared up rapidly under treatment. No results were seen in cases of sympathetic ophthalmia or of disciform keratitis. Krause reviewed the observations of de Decker and Arendt, Grüter, Sattler and Bartels, from which it is difficult to draw conclusions since the best results were obtained in cases of herpetic keratitis of the superficial variety, in which healing often occurs rapidly with other treatment. Results in cases of interstitial keratitis were not definite. Kiewe [10] recorded the temperatures produced by various methods, but details are not given in the available reports of his work.

A number of observers were convinced that dilatation of the retinal vessels could be seen following treatment, but no accurate measurements were made.

In the country, Walker [11] has employed short wave diathermy for patients with opacities of the vitreous following operations for detachment and due to other causes. The apparatus used by him delivers 1,500 milliamperes with small oval electrodes suspended over the eye, and the current is applied for fifteen minutes, with intervals of a minute or so every three minutes. He has seen no burns by this method but stated that care must be taken with more powerful machines. He expressed the belief that the method should be more widely employed by ophthalmologists and that it is of especial value in the treatment of glaucoma secondary to uveitis.

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6. Scheyhing, H.: Klin. Monatsbl. f. Augenh. **98**:387, 1937.
7. Carlotti: Klin. Monatsbl. f. Augenh. **98**:575, 1937.
8. Kuwahara, Y.: Klin. Monatsbl. f. Augenh. **98**:576, 1937.
9. Krause, J.: Ztschr. f. Augenh. **89**:266, 1936.
10. Kiewe, P.: Klin. Monatsbl. f. Augenh. **95**:108, 1935.
11. Walker: Tr. Am. Ophth. Soc. **33**:71, 1935.

It may be concluded that short wave therapy is the most efficient method known of producing heat in the deeper tissues and that it is probably of real value in cases of severe infection of the lids and orbit or of acute dacryocystitis and in certain cases of chronic uveitis. It must be used with care to prevent burns, and further observations as to exact dosage are desirable. It would seem to be contraindicated in cases in which the danger of hemorrhage exists.

FEVER INDUCED BY LONG OR SHORT WAVE DIATHERMY

There can be no doubt that when fever therapy is indicated, the increase in temperature can be efficiently and constantly obtained by diathermy. The blankets with which long wave diathermy was employed have rather generally been replaced by cabinets in which a field of short wave current is generated while the patient is kept dry by the passage of air. The desired temperature can be produced more rapidly in such cabinets than in those employing air conditioning alone. Even when every precaution is taken to replace lost fluid and salt during the treatments, the method is not without danger. Hence it should be reserved for serious conditions which do not respond to other forms of therapy and must not be employed for elderly or infirm patients, especially if increased blood pressure or myocardial lesions are present. It is the routine at the Passavant Hospital to require an electrocardiographic examination in addition to a thorough physical examination before fever therapy in the cabinet is given. The treatment must be supervised throughout by an assistant who is thoroughly familiar with the method and with complicating conditions which may arise during treatment.

Three conditions seem to offer special indications for this form of therapy. The most important of these is gonorrheal ophthalmia in the adult. Pinkerton [12] has reported excellent results in three cases with a temperature of 107 F. maintained for from five to ten hours. Swelling and secretion subsided promptly, and smears became negative twenty-four hours after the first treatment. In two cases corneal ulcers were present when treatment was begun and healed promptly. While no other reports have been seen, the success of the method with other forms of gonorrhea and the severity of the process under former methods of treatment seem to offer a definite indication for the method. Results in the few cases available seem to be definitely superior to those obtained by the usual foreign protein therapy.

The second of the three conditions mentioned is interstitial keratitis. The most complete report on the subject is by Culler and Simpson.[13]

12. Pinkerton, F. J.: Am. J. Ophth. **20**:63, 1937.

13. Culler, A. M., and Simpson, W. M.: Artificial Fever Therapy in Cases of Ocular Syphilis, Arch. Ophth. **15**:624 (April) 1936.

They employed the Kettering hypertherm, an air-conditioned cabinet, producing a temperature of 105 F., which was maintained for five hours. Weekly treatments were given for ten weeks, each treatment being preceded by an injection of bismarsen. They observed eleven patients with twenty affected eyes for eighteen months or longer. At the end of this time no patient had vision of less than 6/30, while vision in eighteen eyes was 6/12 or better. The average period of congestion for the treated patients was two months. Eight of the patients treated had suffered recurrences after other treatment, and ten had failed to respond to chemotherapy. It will be noted that the degree and duration of temperature employed in this series were both considerably less than those used in treating gonococcic infections.

The third condition in which fever therapy seems indicated is atrophy of the optic nerve in syphilis of the central nervous system. Culler and Simpson reported on sixteen patients treated by the same method employed in the cases of interstitial keratitis. Central vision remained the same in practically all cases, and the fields increased in three. A number of cases in which malarial inoculations were used have been reported by Fischer-Ascher, Heinsius, Gasteiger, Clark and others. In general, the results were encouraging to the employment of fever, and the advantages of fever produced in the cabinets over malarial inoculations are obvious. Neymann [14] treated seven patients with syphilitic atrophy of the optic nerve, employing a temperature of 107.6 F. for eight hours. Treatments were given twice a week for ten weeks. Three patients in whom the condition was advanced became blind. Two showed slight improvement in vision, while in two the disease remained unchanged. In most of his cases the condition was advanced when treatment was begun. When compared with the method of cisternal injections, results in a limited number of cases appear more favorable with the latter method, but it must be considered as more dangerous than fever therapy.

On account of the necessary nursing care and the dangers involved, it seems best to reserve high fever therapy for the three conditions just mentioned. Culler and Simpson reported good results in cases of syphilitic iritis, and Whitney [15] used the method in cases of various types of keratitis and iritis, but there seems reason to think that equally good results could have been obtained by simpler methods. The use of a lower temperature (105 F.) and a shorter period (four hours) may

14. Neymann, C. A.: Artificial Fever Therapy, Springfield, Ill., Charles C. Thomas, Publisher, 1937.

15. Whitney, E. L.: Artificial Fever Therapy in Treatment of Corneal Ulcer and Acute Iritis, J. A. M. A. **104**:1794 (May 18) 1935.

prove of advantage in certain cases of intractable chronic uveitis, the dangers of such a temperature being negligible when proper precautions are taken.

ROENTGEN THERAPY

Roentgen therapy has been mentioned as having proved valuable in the treatment of certain types of keratitis. The rationale of the method, in which doses so small as to be perfectly safe are employed, is not clear. It is improbable that bacteria are killed, although there is some evidence that the herpes virus is especially susceptible to roentgen irradiation. It is more likely, as Case suggests, that leukocytes, which are extremely sensitive to roentgen irradiation, are broken down in the tissues, with the liberation of ferments and lytic substances which aid in the body's defensive reaction. Cells involved in the healing of corneal defects may also be stimulated. It is hard to bring scientific proof of such phenomena. Clinical experience, however, has convinced me that one or two exposures to a small dose of roentgen rays may be of great value in the treatment of dendritic ulcer, superficial punctate keratitis, degenerative ulcers or old scars and a few other types of keratitis. Such treatments have been given for me by Dr. James Case in ten cases, chiefly of dendritic keratitis, in most of which the condition had resisted other treatment or had recurred after such treatment. Most of these ulcers healed within one or two days of the first treatment, and a second was seldom required. In no case has any evidence of damage to the lens been seen, which is what could be expected from such small doses. Such treatments are given, of course, without any form of protective shell. From 80 to 90 roentgens of unfiltered radiation with a current of 100 kilovolts was given at each treatment.

Roentgen therapy is of great value in severe cases of blepharitis. Three doses of from 80 to 90 roentgens each are given at intervals of two weeks, a mercury-filled glass or a lead shell being placed beneath the lids to protect the cornea and lens. Blepharitis of many years' standing which has resisted the usual forms of treatment has practically always responded to this treatment. The use of a mild ointment, usually of 2 per cent zinc oxide in hydrous wool fat, is used for some time to dissolve crusts and prevent recurrences. In a few cases a second course of treatment has been necessary after a year or more. Such dosage has never caused loss of lashes in my cases, and no damage to the lens has been observed.

In a few cases of early postoperative and posttraumatic infection results have been encouraging enough to deserve mention, although the number of cases is too small to justify definite conclusions.

SUMMARY

Phototherapy is probably of value in herpetic and a few other forms of superficial keratitis.

Roentgen irradiation in small doses has apparently produced good results in cases of keratitis in which phototherapy has failed and may well replace phototherapy in the treatment of conditions for which it has been employed.

The infra-red lamp is a useful and practical instrument for applying ordinary heat.

Local short wave diathermy may prove to be of considerable clinical value in the treatment of chronic uveitis and of cellulitis of the lids and orbit. Standardization of dosage is desirable.

General fever therapy by the use of diathermy cabinets is of value in cases of gonorrheal ophthalmia, interstitial keratitis and syphilitic atrophy of the optic nerve.

Roentgen therapy is of undoubted value in cases of obstinate blepharitis, dendritic keratitis or superficial punctate keratitis in its more severe forms and possibly in cases of disciform keratitis.

USE OF TYPHOID H ANTIGEN BEFORE INTRA-OCULAR OPERATIONS

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A method of rapidly producing and increasing the antibody titer of the blood by the intravenous administration of typhoid H antigen has been recently described. The beneficial effect of an increased intra-ocular concentration of H antibodies on intra-ocular inflammation has likewise been reported.[1] Briefly, the titer of the blood may rise to 1:100+ in from forty-eight to fifty hours after an intravenous injection of a solution of typhoid H antigen containing 15,000,000 organisms. At this time the titer of the aqueous is usually not measurable. After paracentesis of the anterior chamber, the titer rises to 1:6 or 1:8. This concentration was found to have an inhibiting power on the production of experimental iritis in sensitized rabbits. Higher concentrations could be obtained by further tappings, with consequently greater inhibiting power. This method was applied clinically to patients with various types of uveal inflammation, with marked benefit beyond that previously obtained in the same persons with other accepted local and general procedures.

Use of the same idea in intra-ocular operations as a possible prophylaxis against postoperative inflammation, especially of the uveal tract, was considered logical. It was noticed in rabbits that when the antibody concentration of the aqueous was raised *before* sensitization the inhibiting effect was greater than when it was done after sensitization. The effect was also greater when the titer was raised in the aqueous *before* the activating dose was administered.[2] The aqueous titer in patients with uveitis can be raised only after the activation or onset of disease, because the inflammation is treated only after it occurs. However, when an intra-ocular operation is proposed, the inflammation may be anticipated and the typhoid H antigen given intravenously from forty-eight to seventy-two hours before the operation; the antibody titer of the aqueous is raised automatically by the ocular incision which releases aqueous. The new aqueous formed after closure of the wound is necessarily rich in H antibodies derived from those already formed in the blood by the previous intravenous injection.

1. Brown, A. L.: Am. J. Ophth. **20**:583 (June) 1937.
2. Brown, A. L.: Tr. Am. Ophth. Soc. **33**:435, 1935.

For the past three years this method has been used before intra-ocular operations. At first it was applied only in cases in which post-operative inflammation was feared. The effect was so uniformly good that the procedure was extended to practically all cases, for there seemed to be no contraindication to the dosage used except in aged persons with many degenerative changes who were considered unable to stand any protein shock that might occur. During the latter part of the first year the prophylactic injection was given to all patients before an intra-ocular operation. Since uveal inflammation is infrequent after most operations for glaucoma simplex, the injection was reserved for persons requiring operation for secondary glaucoma, especially those with glaucoma due to uveitis and associated with synechiae, those requiring iridotasis or those showing untoward reactions on a previous occasion.

All patients with cataract are so treated. Verhoeff's and Lemoine's [3] theory of the causation of endophthalmitis after an extracapsular extraction for cataract deals with the probable sensitization to lens cortex, which when released in the anterior chamber activates the eye to inflammation. If this is sound, the enriching of new postoperative aqueous with potent antibodies that inhibit activation is a logical prophylaxis. Whatever the mechanism, this method has shown itself a valuable adjunct in a hundred cases of cataract in which extraction was done, in fifty by the extracapsular method. From fifty to seventy-two hours before operation the patient is given a minim (0.06 cc.) of a solution of typhoid H antigen (25,000,000 organisms to 1 cc.) intradermally. If there is no local reaction within twenty to thirty minutes, a solution containing 15,000,000 organisms is injected intravenously. This may be done at the office and the patient instructed to go home because a reaction may ensue within four to eight hours. Sixty per cent of the patients feel nothing beyond a mild indefinite discomfort; 20 per cent report a slight chilly sensation followed by mild muscular soreness the next day. Twenty per cent suffer from shock, having malaise, chills and fever, with temperature as high as 103 F., which subsides in from two to four hours, leaving them with muscular aches described as "a grippy feeling." These patients do not object to the reaction when the purpose of the therapy is explained. The hundred cases in which this method was used are not reported in detail because postoperative inflammation occurred in but one case. In this case it appeared three days after an apparently uneventful recovery, accompanied by violent pain, redness and a peculiar clouding of the stroma of the cornea from below and extending upward. The tension rose on the fourth day to 55 mg. (Schiötz). The anterior chamber was tapped, and the tension

3. Verhoeff, F. H., and Lemoine, A. N.: Internat. Cong. Ophth. **1**:234, 1922.

subsided. The eye remained irritated, but with normal tension, for four weeks thereafter. At the time of the writing of this report the corneal haze had persisted for six months but seemed to be slowly clearing. It is possible that in this case the posterior layer of the cornea was injured during operation.

When an eye is perforated accidentally in any manner, typhoid H antigen is immediately given intravenously after a negative cutaneous test. If the wound is purely ocular, the preference is given to the antigen rather than to antitetanic serum, unless there is a definite reason to fear the material coming in contact with the patient at the time of injury. If there are extensive wounds in the skin beside the ocular injury, the treatment depends on the circumstances. The serums have not been given together, but this may be feasible.

OCULAR MANIFESTATIONS OF ENDOCRINE DISTURBANCE

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Although much is known about the functions of the endocrine glands, their study still remains the most fertile field for advancement in medicine. The actions of these glands are so greatly influenced by environment, vitamins, chemicals and emotional states that the results of animal experimentation are not conclusive. The action of one gland is so intimately bound up with the actions of all the other glands that it is almost impossible to isolate hyperfunction or hypofunction of any single gland. In an effort to make up for the deficiency of a hypofunctioning gland, other glands may develop hyperfunction of their primary secretions or of their component glands. Then the vitamins, which are to plant life what the hormones are to animal life, are essential to the proper functioning of the endocrine system. Finally, biochemical reactions and the nervous system regulate the endocrine function, and the endocrine function controls the biochemical process and the nervous system.

Because of this complexity and the interrelation of the various endocrine glands, the nervous system and the biochemical processes, it can readily be seen that the clinical symptoms and physical characteristics render the most reliable information applicable to clinical medicine.

Because of the facility of studying directly under magnification the living ectoderm, mesoderm and, to a lesser degree, entoderm, and because of the dual control system of the vagus and sympathetic nerves, the eye provides an excellent medium for the study of endocrine disturbances.

Since such a field is available for the study of endocrine disturbances, it behooves the ophthalmologist to train himself to recognize the various signs of endocrine malfunction in order better to qualify himself as a consultant in and a practitioner of ophthalmology.

No effort will be made to review the extensive literature, as that has been done completely by von Szily [1] and Velhagen.[2]

Read at a meeting of the American Academy of Ophthalmology and Otolaryngology, Chicago, Oct. 14, 1937.

1. von Szily, A.: On the Pathological Relation of the Visual Organs to Endocrine System, Zentralbl. f. d. ges. Ophth. **33**:161, 1935; About Different Eye Diseases Which Are Thought to Be Related to Endocrine Disease, ibid. **34**:193, 1935.

(Footnote continued on next page)

The autonomic nervous system is so intimately associated with the function of the endocrine system and the eye that a brief review is essential to a clear understanding of the action of the endocrine glands in relation to the eyes. The autonomic nervous system is not an independently controlled nervous system but an involuntary outflow from the cerebrospinal nervous system with peripheral plexuses at the sites of distribution which are connected by neurons to the cerebrospinal system. These are subdivided into the sympathetic, parasympathetic and visceral systems. The sympathetic system comprices the thoracolumbar outflow, while the parasympathetic system includes the cranial and sacral outflows.

Hyperstimulation of the parasympathetic system (vagotonia) results in an increase in salivation, perspiration and lacrimation, dermal and vasomotor changes and motor reactions, manifested by contraction of the pupils, spasm of accommodation, contraction of the respiratory tract, spastic colon and rectal tenesmus, while hyperstimulation of the sympathetic system results in a decrease in lacrimation, perspiration and salivary secretion, dilatation of the pupil, an increase in the pulse rate and colonic-rectal atony. In other words, the sympathetic and the parasympathetic system when supplying the same organ act antagonistically. Some organs are supplied only by the sympathetic system, and in these the sympathetic nerves have an added mild parasympathetic action.

The adrenal medulla, the anterior lobe of the pituitary gland, the thyroid gland and the gonads stimulate the sympathetic nervous system, while the posterior lobe of the pituitary gland and the adrenal cortex stimulate the parasympathetic system. Pilocarpine stimulates the vagus system, while atropine paralyzes its terminals.

Before one attempts to attribute any ocular manifestation to an endocrine disturbance, other disease entities should be sought for and eliminated, because in the presence of any other disease one is not justified in making a definite diagnosis of endocrine disease.

Determinations of the blood sugar, nonprotein nitrogen, urea, calcium, uric acid, cholesterol and chlorides are of value in arriving at a diagnosis. For the blood sugar is affected by the pancreas and the thyroid, adrenal and pituitary glands; the nonprotein nitrogen, urea, uric acid and creatinine, by the adrenals, the thyroid and the pancreas; calcium, by the parathyroid, and cholesterol, by the thyroid.

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2. Velhagen, K., Jr.: Observations on Disturbances of the Endocrine System and the Eye, Klin. Monatsbl. f. Augenh. **96**:577, 1936. von Szily, A.: Disturbances of the Endocrine Secretions and Their Effects on the Eye, Zentralbl. f. d. ges. Ophth. **32**:97, 1934.

THYROID GLAND

Of all the endocrine glands, the function of the thyroid is best known, and apparently any deviation from the normal most frequently affects the eyes, either because it is more frequently recognized or because it has a greater influence on the appearance of the eye.

The internal secretion of the thyroid gland assists in the stimulation of the sympathetic nervous system and mentality and acts as a catalytic substance, expediting metabolic processes and facilitating chemical changes in all the cells of the body, especially reactions involving iodine, calcium, sodium chloride and phosphorus. It influences the function of the pancreas, the pituitary gland and the gonads.

As is well known, the basal metabolic test is unreliable unless several tests are made. The determination of the cholesterol content of the blood is perhaps more reliable, as the value is low in cases of hyperthyroidism and high in cases of hypothyroidism. However, the cholesterol content is also increased by an excess of vitamin D and lowered by a deficiency of vitamin D. Because of this unreliability of laboratory procedures, recognition of the ocular signs of dysfunction of the thyroid gland is of great importance in arriving at a diagnosis.

The most striking ocular sign of hyperthyroidism is exophthalmos, usually binocular. This is due to a round cell infiltration and edema of the muscles and orbital tissues. In some cases the exophthalmos is aggravated by thyroidectomy. In such cases the condition seems to be due to hyperadrenalism, and Crile has brought about relief in many of them by denervation of the adrenal gland. If the exophthalmos is not relieved, lagophthalmic keratitis may develop, resulting in troublesome ulcers or loss of the eyes.

Other ocular signs associated with hyperthyroidism, alone or in conjunction with exophthalmos, are: Graefe's sign, failure of the lids to follow the downward motion of the globe; Stellwag's sign, diminution in the frequency of blinking; Dalrymple's sign, deficiency of convergence, and Gifford's sign, a transverse ridge on eversion of the upper lid due to spasm of the orbicularis muscle. These signs are all the result of hyperstimulation of the sympathetic nervous system. There may also be muscular paralysis or heterophoria as the result of pressure and dilatation of the pupils due to hyperstimulation of the sympathetic system.

In cases of hypothyroidism the skin of the lids is edematous, the eyebrows and eyelashes are sparse and brittle, and there may be marginal blepharitis, eczema and chronic conjunctivitis. Enophthalmos may be present. In an occasional case nystagmus has been ascribed to hypothyroidism. In cases of marked hypothyroidism there is a yellowish fold of edematous conjunctiva in the lower cul-de-sac. Lacrimal secre-

tion is diminished, and the frequency of blinking and squinting is increased, in some cases markedly. Syphilitic interstitial keratitis occurs much more frequently in patients with hypothyroidism than in those with normal thyroid function, and the excellent and rapid results obtained in such patients with fever therapy are most likely due to stimulation of the thyroid and adrenal glands, which in turn stimulate the reticulo-endothelial cells. Myopia and opacities of the lens are frequently associated with hypothyroidism. Multiple noninfected chalazia are frequently the result of this condition. I have found the incidence of hypothyroidism high in cases of cortical cataract. Strabismus has frequently been found associated with hypothyroidism.

I have found that hypothyroidism may easily be overlooked in the children of the more prosperous classes. It should always be suspected in children with chronic eczema or catarrh.

Photograph of the fundus illustrating edema of the retina as seen in cases of hypothyroidism.

I have associated with hypothyroidism a sign not previously reported, viz.: edema of the retina around the disk and macula, extending into the retina as much as 4 or 5 disk diameters. I have found the disk elevated as much as 3 diopters and the vision reduced to 20/40 by this edema. At first this condition was attributed to allergy, but in a number of cases it was not possible to demonstrate allergy to any known allergen. Further investigation demonstrated deficient function of the thyroid gland in most of the nonallergic patients. In addition, I was able to demonstrate such a deficiency in most of those in whom allergy was present.

The only reference found relative to retinal changes associated with hypothyroidism was by Engelbach,[3] who stated: "The retinal signs present in some cases of myxoedema are often thought to be albuminuric retinitis." His description represents the condition as found in patients with severe edema of the retina, but in those with mild edema a low

3. Engelbach, W.: Endocrine Medicine, Springfield, Ill., Charles C. Thomas, Publisher, 1932, vol. 3, p. 325.

grade hyperthyroidism can usually be confirmed by several basal metabolic tests, determination of the cholesterol content of the blood and a therapeutic test.

PARATHYROID GLANDS

The parathyroid glands control the metabolism and assimilation of calcium and phosphorus, which act as a sedative to the irritating effects of sodium on the nerves of the voluntary and involuntary muscles. Consequently, with deficiency of the secretion of the parathyroid glands, symptoms of calcium deficiency develop, that is, increased muscular rigidity with fine tremors of the voluntary and involuntary muscles. This deficiency has been termed diabetes calcareus. It has been suggested that vitamin D may have a part in regulating the function of the parathyroid glands.

I have observed no ocular manifestations of hyperparathyroidism. Lack of secretion of the parathyroid glands disturbs calcium metabolism, resulting in a vagotonic activation of muscle tissues, and may be reflected in clinical ophthalmology as ciliary spasm, blepharospasm and idiopathic spastic entropion, twitching movements of the lids and eyeballs and hypersecretion of tears. The calicum disturbance may produce zonular cataract. There is a close association between cataract and parathyroid tetany in children. I have seen strabismus unassociated with refractive errors develop during convulsions which most likely were the results of acute hypoparathyroidism, since 90 per cent of convulsions in children before 2 years of age are due to this condition.

PITUITARY GLAND

The anterior lobe of the pituitary gland regulates growth and development and has a great influence on the gonads, the mammae and the thyroid and adrenal glands. It stimulates the sympathetic nervous system and assists in the metabolism of protein, fats, water calcium, etc. After removal of the anterior lobe, the adrenal cortex and gonads atrophy. Part of its action on the eye is through its effects on the sympathetic and parasympathetic nervous systems.

Opacities of the lens are seen in conditions due to hyperfunction, such as acromegaly. During pregnancy there is a physiologic enlargement of the pituitary gland, causing bitemporal contraction of the visual field. When there is marked enlargement of the pituitary gland the fields usually show bitemporal hemianopia and occasionally atypical defects. Contrary to the general belief, pathologic enlargement of the pituitary gland does not always produce bitemporal contraction, but one or both fields may be concentrically contracted, or, if only the posterior lobe is enlarged, one of the optic tracts may be involved, with the production of homonymous hemianopia. These changes are asso-

ciated with blurred vision or amaurosis, with swelling of the optic disk and, eventually, with secondary atrophy of the optic nerve. With most of these enlargements there is more or less headache. In cases of tower skull, which usually is associated with hyperpituitarism, the orbit and the optic foramen are contracted. In minor disturbances there may be a transitory disturbance of the visual fields and scintillating scotoma.

Hypofunction of the anterior lobe of the pituitary gland has been suggested as a cause of retinitis pigmentosa. In thirty-five cases in which retinitis pigmentosa was present the condition has been reported as the Laurence-Biedl syndrome. I have seen this syndrome in a brother and sister, but the cases have not been reported. They had a Fröhlich type of obesity, deformity of the skull, retarded mental development and retinitis pigmentosa. Hypothyroidism is also usually present in such cases. The use of an extract of the anterior lobe of the pituitary gland in conjunction with thyroid has been suggested in the treatment of cretinism, because of the frequent finding of a small sella turcica in cretins.

The function of the posterior lobe of the pituitary gland is that of stimulating the sympathetic nervous system and the involuntary muscles. It influences the metabolism of sodium chloride, water and carbohydrates. Hyperfunction of this lobe produces hyperstimulation of the sympathetic nervous system, increases pigmentation and increases smooth muscle tone. The secretion of this lobe consists of a pressor principle which is more persistent than epinephrine and acts synergistically with it. It acts as an antidiuretic, as in diabetes insipidus.

Angioneurotic edema is sometimes associated with dysfunction of this lobe. Lenticular opacities associated with diabetes insipidus are sometimes found. Night blindness may result from hypofunction. Patients suffering from hypofunction of the posterior lobe have heavy superciliary ridges, shaggy eyebrows and thick lashes and frequently blepharitis. Mild ptosis may be a result of a hypofunction of this lobe.

In cases of combined dysfunction of the pituitary gland and gonads are found seborrhea and acne that may involve all ectodermal structures, such as the skin, conjunctiva, cornea and lens. Leber's disease (hereditary atrophy of the optic nerve) has been placed by some observers in the category of disturbances of the pituitary gland. Zentmayer noted definite changes in the sella turcica in a number of cases, and restoration of vision has been reported after the use of pituitary extract.

ADRENAL GLAND

The adrenal gland is essential to animal life. It is made up of two parts, the cortex and the medulla, each having a distinct action. The cortex is the part of the gland indispensable to life.

The cortex assists in regulating the concentration of sodium and of potassium in the body, controls pigmentation, stimulates the parasympathetic system and neutralizes toxins. It assists in the assimilation of vitamin C (cevitamic acid) and in that way should act favorably on cataract due to vitamin C deficiency. With deficiency of the cortex there are a loss of sodium and a retention of potassium, thereby causing an alteration of sodium-potassium ratio. This is followed by loss of water and loss of weight, which result in an increase in the nonprotein nitrogen and the urea content of the blood. Deficiency of the cortex results in a lowering of the blood sugar and glycogen stores and in an increased sensitivity to insulin. With marked deficiency of the adrenal cortex the skin becomes irregularly pigmented and darkened as a result of dehydration. There occur also diminution in oxygen consumption, muscular weakness, an increase in capillary permeability and, in extreme cases, circulatory collapse resembling histamine shock.

Hypofunction of the adrenal cortex may result in enophthalmos, and occasionally tumor or hyperplasia of the adrenal cortex is the cause of exophthalmos.

The medulla of the adrenal gland affects the pancreas, and apparently its secretion is antagonistic to insulin, thereby increasing the blood sugar, and it may cause sugar to appear in the urine. It stimulates the function of the thyroid gland, and their combined actions regulate the body temperature and metabolism. The secretion of the adrenal medulla contains pressor principle, its effect being more rapid but of shorter duration than the secretion of the posterior lobe of the pituitary gland. It is a definite stimulator of the sympathetic system and causes contraction of the smooth muscles, thereby affecting muscle tone and vasomotor control.

Myopia and, in some cases, glaucoma have been attributed by some to deficiency of the adrenal gland.

PANCREAS

The internal secretion of the pancreas controls carbohydrate metabolism. The external secretion controls digestion of fats and regulates the alkaline reserve.

In cases of hypo-insulinism there is an increase in the blood sugar, resulting in heightened susceptibility to pyogenic infections. By sudden lowering of the blood sugar there may be produced swelling of the lens with rapid refractive changes. Previously existing lenticular opacities may progress to maturity, or opacities may form in a previously clear lens. Uveitis may be caused by hypo-insulinism. There may be retinal hemorrhages or even massive hemorrhages into the vitreous as a result of changes in capillary permeability. However, hemorrhages

in the retina in these cases are most commonly due to vascular changes, the result of a prolonged increase in the blood sugar. Retinal lipemia may also be a result of hyperglycemia.

GONADS

The gonads are not self-regulating organs that control their own function. The anterior lobe of the pituitary gland is the main regulator of the activity of the sex glands. The adrenal cortex is also a gonadal stimulant. The thyroid gland, either through its interrelation with the pituitary gland and the adrenal cortex or by direct action on the gonads, also is a factor in gonadal stimulation, but this function is not well understood.

The gonads stimulate the sympathetic nervous system. As a result, patients with deficiency of gonadal hormones exhibit symptoms of hyperstimulation of the parasympathetic system, as manifested by vagotonia.

I have had a number of patients with hypogonadism with definite signs of hyperstimulation of the parasympathetic system or vagotonia. Most of the patients complained of blurred vision and had marked discomfort in the eye, with rather constant headaches and inability to use the eyes without discomfort. No abnormalities of the eyes could be found. Many of them manifested symptoms of sinus disease, including enlargement of the blindspot. Most of the patients had consulted several reliable oculists previously, with only temporary or no relief from the symptoms. Many of them were relieved by the administration of anterior pituitary extract, even castrated women responding to the treatment, and in one case the blindspot returned to normal in ten days. Of all the procedures I have used in the practice of ophthalmology, this is one of the therapeutic measures most appreciated by patients.

I have had a few male patients with hemorrhage in the retina and vitreous who gave positive reactions to tourniquet tests and whose condition did not respond to cevitamic acid, although no other cause could be found to account for the hemorrhages, but who immediately responded to whole ovarian substance and gave a negative reaction to the tourniquet test. After the administration of ovarian extract was discontinued, the hemorrhages returned and the tourniquet test again became positive. I diagnosed the condition of these patients as mild hemophilia, for which the treatment is administration of whole ovarian substance.

COMMENT

In the literature many ocular diseases have been attributed to endocrine disturbances. Glaucoma has frequently been mentioned as being of endocrine origin. There are so many types of glaucoma that it could

not be expected to be the result of a single endocrine syndrome. Cases have been reported in which the cause was thought to be hyperthyroidism, hypothyroidism, hyperpituitarism, hypopituitarism, allergy due to splenic deficiency, hypofunction of the adrenal cortex or gonadal deficiency. I have seen several patients in whom glaucoma was apparently due to endocrine dysfunction, but in none of them was it due to the deficiency of a single gland and in no two cases was the condition identical. I have used extract of adrenal cortex with a spectacular drop of intra-ocular tension after the first injection but with no results on subsequent injections. Likewise, I have used tissue extract with no definite results.

Some cataracts have been placed in the category of endocrine disturbances by a number of authors, and cataracts have been attributed to hypofunction of the pancreas, the parathyroid glands, the thyroid gland, the gonads and the adrenal cortex and to hyperfunction of both the anterior and the posterior lobe of the pituitary gland. I have seen patients with cataracts with associated dysfunction of all the aforementioned glands, but the one finding most frequently encountered in patients with cataract (both the congenital and the senile cortical type) is hypothyroidism, and in a great number of these cases there is also an associated hypogonadism.

Myopia is frequently ushered in by spasm of accommodation and can frequently be greatly diminished by the use of atropine. Physiologically, a spasm of accommodation should be due to hyperstimulation of the parasympathetic system or possibly to hypostimulation of the sympathetic system. On a physiologic basis, acquired myopia may possibly be due to endocrine disturbances, either hyperactivity of the adrenal cortex or the posterior lobe of the pituitary gland or hypoactivity of the anterior lobe of the pituitary gland, the adrenal medulla, the thyroid gland and the gonads.

Keratoconus has also been reported by several authors as being of endocrine origin. Some feel it to be due to deficiency of the thyroid gland and others consider it polyglandular in origin. Others are of the opinion that it is due to calcium deficiency, probably of parathyroid origin. The findings of these authors were not conclusive; however, I feel that there probably is a relation to some endocrine dysfunction not yet fully understood.

Some authors have associated trachoma with status thymolymphaticus, deficiency of the pituitary gland and adenoids. Their findings were not convincing.

Uveitis has been reported in association with endocrine disturbance, but except when it was due to diabetes the symptoms in most of the cases were only suggestive of an endocrine dysfunction.

Retinitis pigmentosa has been associated with dysfunction of most of the endocrine glands, but on a physiologic basis it is not likely to be associated primarily with any gland but the pituitary or the adrenal.

In fact, some authors have attempted to associate practically every clinical entity in ophthalmology with certain endocrine dysfunctions, but most of their contentions have little merit.

I do not wish to convey the impression that endocrine therapy is essential in all conditions that are enumerated as being endocrine in origin. It is well realized what the proper emotional environment will do to endocrine imbalance. Likewise, a vacation to the country will frequently readjust a marked endocrine imbalance. However, there are so many patients who cannot be sent to the country and whose environment cannot be adjusted that it becomes necessary to treat such patients as well as some dysfunctions that are primary in nature, and for these endocrine therapy is essential.

CONCLUSION

In conclusion, I wish to emphasize that the eye is the most fertile field for the study of endocrine disturbance and that it is the duty of every ophthalmologist to study the numerous manifestations of the various endocrine disturbances in order better to qualify as a consultant.

Many of the heretofore hopeless problems are being solved by studies of the endocrine system, and it is hoped that the day will come when many progressive conditions will be arrested by endocrine therapy.

A TENTATIVE INTERPRETATION OF THE FINDINGS OF THE PROLONGED OCCLUSION TEST ON AN EVOLUTIONARY BASIS

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No comprehensive and single hypothesis has been put forward to account for the phenomena grouped under the term heterophoria. Certain conditions underlying it have been mentioned, such as overdevelopment, faulty insertion or length of the muscle. The so-called declinations described by Stevens have also been considered responsible for some of these phenomena. Aniseikonia, too, has been mentioned as a possible cause, as has paresis or partial paralysis. The chief character of these anomalies is their variability.

These conditions may be said to be underlying anatomic states rather than causes. It is necessary to take a step farther back and ask what is the cause of these underlying states. It seems lacking in reason to attribute a variety of possibly causative conditions to phenomena which are fairly uniform in their manifestation, if one excludes the cases in which the etiologic factor is definitely paralysis or trauma.

When the subject is approached from an evolutionary standpoint, it is necessary to bear in mind some elementary principles. First, variation is a fundamental law of nature, all individuals, structures and functions varying within certain ill defined limits, all being equally normal but some more advantageous than others and therefore tending to survival.[1]

Second, all structures and functions may be divided into two classes, the purposive and the nonpurposive. The purposive are those that have developed in response to the necessity for adaptation to changing environment and conditions of life and still perform certain definite and essential functions. The nonpurposive are those which serve no useful purpose and can be regarded as rudimentary or vestigial or as reversions to an earlier, originally purposive, type. Darwin has shown that these rudimentary or nonpurposive structures and functions are more liable to variation than those that remain purposive, the latter being

1. "The muscles are eminently variable. Mr. J. Wood has recorded the occurrence of 295 muscular variations in thirty-six subjects, and in another set of the same number no less than 558 variations" (Darwin, C.: The Descent of Man, New York, D. Appleton & Co., 1871).

subject to natural selection and therefore under control, whereas the former are uninfluenced by it.

According to Peter Chalmers Mitchell,[2] in the "Encyclopedia Britannica":

> The innumerable cases of structures which are rudimentary and apparently useless, in species the close allies of which possess well developed and functionally important homologous structures, are readily intelligible on the theory of evolution while it is hard to conceive their raison d'être on any other hypothesis.

It is necessary in the first place to call attention to the fact that at an early evolutionary stage there is no binocular vision, the eyes being placed laterally.

In his Bowman Lecture on "Arboreal Life and the Evolution of the Human Eye," Treacher Collins[3] stated:

> Animals, such as the terrestrial herbivorous mammals, who require panoramic vision, have their eyes set laterally in the head so as to obtain the largest circumferential effect of the combined monocular fields. Lindsay Johnson measured the divergence of the optical axes in a large number of representative animals, and constructed a diagram graphically showing how it varies in the different natural orders, families, genera and species. From this it seems that the most laterally placed eyes are met with among Rodentia, the Marsupialia and the Ungulata. The greatest divergence is in hares, whose optical axis in each eye measures 85° of divergence from the middle line. It seems probable that they, and some of the other rodents, have complete panoramic vision, i. e., are able to see in their circumference at one and the same time.
>
> Among the Carnivora the smallest amount of divergence is in lions and cats, in which it is less than 10° in each eye. The Simiae and man alone among mammals have parallel optic axes.
>
> This movement forward of the optical axes toward parallelism is clearly in the interests of binocular vision, and at the sacrifice of the range of simultaneous circumferential vision. As ontogeny is a condensed recapitulation of phylogeny, it is interesting to note that in the human embryo the optic vesicles when first formed are directly opposite to one another, from which position they gradually turn forward so that at the third month of fetal life the optic axes of each eye diverge 45° from the middle line; before birth they become parallel.

Thus the evolution of the race and the development of the individual concur in furnishing an explanation, at any rate for the lateral deviations, particularly exophoria. Orthophoria, or parallelism of the visual lines, is evidently the goal aimed at, but the attainment of it often falls more or less short, leaving exophoria of varying degrees, with or without hyperphoria (in about 78 per cent of cases, according to the prolonged occlusion test), esophoria, with or without hyperphoria

2. Mitchell, Peter Chalmers, cited in Evolution, in Encyclopaedia Britannica, ed. 11, London, Encyclopaedia Britannica Company, Ltd., 1910, vol. 10, p. 33.

3. Collins, E. Treacher: Arboreal Life and the Evolution of the Human Eye, Philadelphia, Lea & Febiger, 1922.

(in a small minority of cases—about 13 per cent). Pure esophoria occurs in only 2.2 per cent, pure hyperphoria in 5.5 per cent and orthophoria in only 3.4 per cent, this being no doubt due to the fact that cases are selected on the basis of a presumption of some muscle imbalance. This probably underestimates the prevalence of orthophoria in the community at large.

THE PHORIAS

The findings of the occlusion test in a large group of cases may be classified as follows:

1. Of 700 cases in which the occlusion test was limited to one eye, orthophoria was present in 3.4 per cent. Had the test been carried out on each eye, the percentage of orthophoria undoubtedly would have been less, judging from subsequent experience. This small percentage is perhaps due, as previously suggested, to the fact that the cases were selected on the presumption of the presence of muscle imbalance, and therefore the occurrence of orthophoria should be greater in the community at large.

2. Exophoria was present in 78 per cent of the 700 cases. As already indicated, this can be regarded as a rudimentary condition, the product of the failure of evolution and development to attain parallelism. It varied from 1 to 30 degrees, all normal variations. There was no evidence of primary or secondary deviation and consequently no suggestion of paresis.[3a]

Maintenance of single vision in such cases is automatic, even when the degree of exophoria is high. Thus, in a patient with 30 degrees of exophoria, after occlusion diplopia never occurred, and the patient showed no ability to diverge at will. Occasionally, however, a patient is seen who can maintain fixation with one eye and diverge with the other, a distinct reversion to an earlier type of muscle balance. Thus in two cases reported by W. L. Phillips[4] in 1906 it was possible for the patients to fix with both eyes and at the same time to turn either one out and back again to fixation while reading or to converge or diverge both simultaneously without diplopia.

3. Esophoria, or a convergent position, sometimes results when the advance from a divergent position toward parallelism is overdone. Esophoria, with or without hyperphoria, occurred in 13.2 per cent of

3a. In this article the word "paresis" is used in its strict sense of partial paralysis, and its nature is consequently shown by the presence of a primary and a secondary deviation, the latter being of higher degree than the former. The diagnosis of paresis must depend on the presence of this phenomenon.

4. Phillips, W. L.: A Man Having Ocular Movements Similar to Those Found Normally in Ungulates, Am. Med. **11**:428 (March) 1906.

the 700 cases. Pure esophoria occurred only in 2.2 per cent and consequently is a rare condition. Altogether, there were lateral deviations in 91.2 per cent of cases. There was no evidence of paresis in these cases.

These three conditions, exophoria, orthophoria and esophoria, constitute in the 700 cases a continuous series of variations of the position of rest in the horizontal plane from at least 30 degrees out to 16 degrees or more in.[5]

4. Hyperphoria is commonly described, without any attempt at differentiation, as a condition in which one eye has a tendency to deviate higher than the other. It may be divided into several types. It was present in 84 per cent of the cases, either alone or with lateral deviations.

(*a*) The first type is a definite one in which hyperphoria shows only when one eye is covered and not at all when the other eye is covered.

This is a matter of clinical importance. If occlusion is done on one eye only, the condition may be entirely missed. I recall a case of severe asthenopia seen some years ago in which I occluded one eye only. During occlusion the asthenopic symptoms disappeared entirely. At the end of the period of occlusion a perfect orthophoria was found, and on removal of the ground glass the symptoms returned. Subsequent experience makes me feel sure that if the other eye also had been occluded an explanation of the symptoms would have been found.

In this connection the case of Mr. K. R. S. is in point. He had severe neurasthenic symptoms, including sick headache for many years, without benefit from treatment. Occlusion of the left eye for eight days brought out no deviation, either vertical or lateral, as shown by chart 1. When the right eye was occluded, right hyperphoria (from 2 to 3 degrees) without lateral deviation developed. A partial prismatic correction of this deviation gave complete relief from symptoms.

Again, a patient who had been under my observation from early in life finally showed left hyperphoria of 4 degrees previous to occlusion, with the persistence of neurasthenic symptoms and headache in spite of refractive and muscle correction; after occlusion of the left eye for six days, 11 degrees of left hyperphoria (chart 2) was noted. When the right eye was occluded, the hyperphoria disappeared entirely or changed to a low degree of right hyperphoria. A fuller correction of the left hyperphoria gave great but not complete relief.

In a third case the patient had sick headache and showed 4 degrees of exophoria and a low degree of right hyperphoria at first (chart 3). When the left eye was occluded, 10 degrees of exophoria developed

5. The tropias were not included.

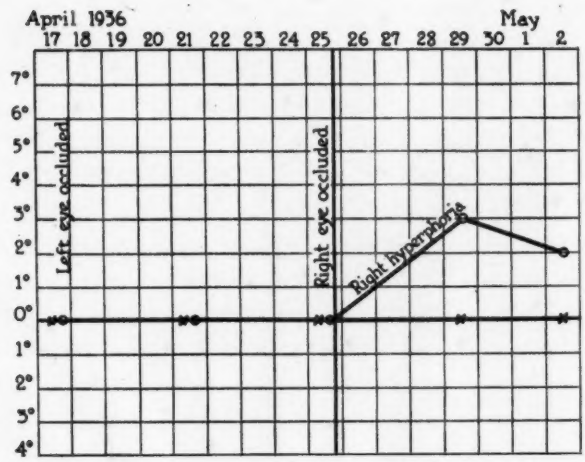

Chart 1.—Uncomplicated unilateral hyperphoria. In this and the following charts the cross (*x*) indicates a lateral deviation—exophoria if the cross is above the zero line and esophoria if it is below it. The circle (*o*) indicates a vertical deviation—right hyperphoria if it is above the zero line and left hyperphoria if it is below it.

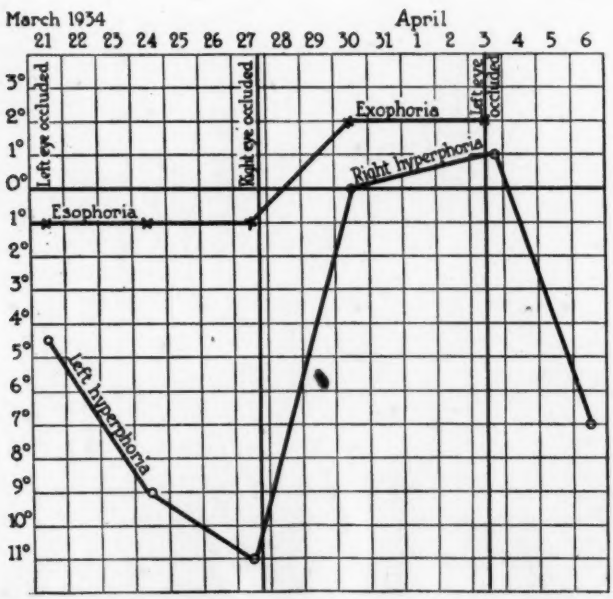

Chart 2.—Unilateral hyperphoria with low exophoria.

and no hyperphoria. When the right eye was occluded for five days, the exophoria increased to 13 degrees, and right hyperphoria of 8 degrees was present.

The conditions in these cases can be explained only by considering them reversions to an earlier evolutionary level in which the two eyes worked independently of one another, there being no interocular innervation; they are not consistent with the paretic theory, there being no evidence of primary or secondary deviation. On one side the elevator muscles balance the depressors in the horizontal plane. On the other side the plane in which they balance is above the horizon. In the prefusion period it was of no importance whether the vertical muscles

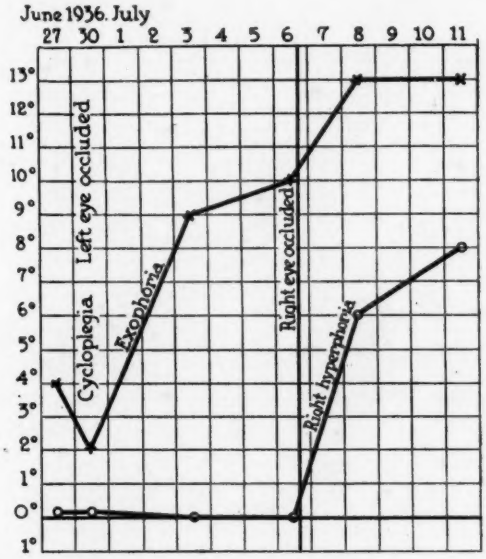

Chart 3.—Unilateral hyperphoria with high exophoria. Note the high degree of hyperphoria in these cases.

balanced in the same plane or not. Such differences may be regarded as normal variations. When occluded, the eye seeks its position of rest.

The alternative hypothesis, that some of these vertical deviations are due to paresis of one or more muscles, can be shown to be inapplicable in a large majority of the cases by a study of what seem to be primary and secondary deviations, whereas even in the cases which are consistent with the paretic theory the rudimentary theory affords just as satisfactory an explanation and is more in keeping with the usual.

(*b*) In the second type of hyperphoria a similar condition exists on each side, and each eye when covered deviates upward and comes

to rest above the horizontal plane. In other words, there is a *bilateral vertical deviation,* commonly known as double hyperphoria (anophoria). Hyperphoria is commonly greater on one side than on the other—anophoria plus hyperphoria. There is here certainly no evidence of any weakness of the muscles or of any primary or secondary deviation; consequently, the explanation must be some faulty relation, either in length or in insertion, of the vertically acting muscles. Each eye when released from fusion seeks its position of rest.

A good example of this type is shown in a case of progressive myopia (chart 4). At the preocclusion test orthophoria was present;

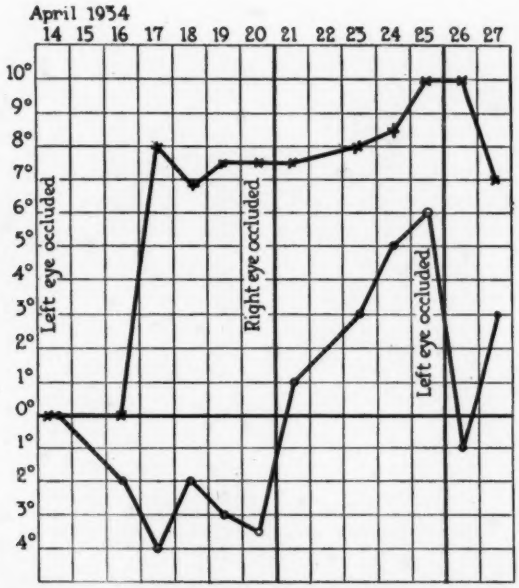

Chart 4.—Bilateral hyperphoria with exophoria (double hyperphoria).

with the left eye occluded there was left hyperphoria of 4 degrees, and with the right eye occluded, right hyperphoria of 6 degrees.

(*c*) In the third type the same kind of hyperphoria of moderate or low degree is found on each side, but it is usually greater on one side than on the other. In some cases, but not all, the condition suggests a primary and secondary deviation, but in all it is consistent with the variation theory of the position of rest—a nearer approach by evolution and development to orthophoria.

Thus, in the case of Mrs. H. A. V. (case 6 in the table), when the left eye was occluded, the right eye functioning, left hyperphoria of 3 degrees and exophoria of 9 degrees developed, the hyperphoria being greatest up to the left, indicating an insufficiency of the right inferior

oblique muscle. When the right eye was covered, the left functioning, the left hyperphoria decreased to 1 degree, the exophoria being 10 degrees. This might be an instance of primary and secondary deviation and therefore of paresis, but variation might equally well account for it. On the other hand, in the case of Mrs. J. H. T. (case 7 in the table), when the left eye was occluded, the right functioning, right hyperphoria of 0.5 degree and exophoria of 8 degrees developed. When the right eye was occluded, the left functioning, the right hyperphoria

Relation, or Lack of Relation, of the Underacting Muscle to the Kind of Deviation (Hyperphoria) Present

Case No.	Relatively Underacting Muscles*	Eye Occluded		Diagnosis
		Right	Left	
1.....	Right inferior rectus	4.5° right hyperphoria	3° right hyperphoria	Variation
2.....	Right superior oblique	0.5° right hyperphoria	2.5° right hyperphoria	Paresis or variation
3.....	Left inferior rectus	2° left hyperphoria	7° left hyperphoria	Variation
4.....	Right inferior oblique	1° left hyperphoria	6.5° left hyperphoria	Paresis or variation
5.....	Right inferior rectus	2.5° right hyperphoria	0.25° right hyperphoria	Variation
6.....	Right inferior oblique	1° left hyperphoria	3° left hyperphoria	Paresis or variation
7.....	Right inferior rectus	3° right hyperphoria	0.5° right hyperphoria	Variation
8.....	Right inferior rectus	3.5° right hyperphoria	0° hyperphoria	Variation
9.....	Right inferior rectus	3.5° right hyperphoria	2° right hyperphoria	Variation
10.....	Right inferior rectus	3° right hyperphoria	0° hyperphoria	Variation
11.....	Right inferior oblique	3.75° left hyperphoria	0° hyperphoria	Variation
12.....	Right inferior rectus	6° right hyperphoria	1° right hyperphoria	Variation
13.....	Right inferior oblique	3° left hyperphoria	0° hyperphoria	Variation

increased to 3 degrees and the exophoria to 10 degrees, the hyperphoria being greatest down and to the right. In other words, in spite of the insufficient muscle in the right eye, the vertical deviation was greatest when the left eye was functioning, a situation not consistent with the paretic theory.

Mrs. B. T. (case 8 in the table) showed right hyperphoria of 2 degrees at the preliminary examination. When the left eye was occluded the right hyperphoria changed finally to left hyperphoria of 1 degree. When the right eye was occluded, the left eye functioning, the right hyperphoria returned and finally measured 3.5 degrees. In this case the right hyperphoria was greatest down to the right. The right eye,

containing the paretic muscle, should have produced, when functioning, a greater deviation than that of the left eye. This was not the case. These two cases cannot be explained on the basis of paresis.

I have included in the accompanying table data on a series of unselected cases in which the deviation was of the same kind but of different degrees on the two sides and therefore possibly of a paretic nature. If not of a paretic nature, the only alternative would seem to be the natural chance anatomic variations. Even in those cases in which the deviations were of the primary and secondary types associated with the paretic theory, they might be equally well explained on the variation principle.

(*d*) In another type the relative position of rest of the two eyes is the same in kind and degree whichever eye is covered.

Thus, in the case of Mrs. E., when the left eye was covered 2 degrees of left hyperphoria developed. When the right eye was covered 2 degrees of right hypophoria was brought out. Or, to put it in other words, when the left eye was occluded the left eye turned up (left hyperphoria), and when the right eye was occluded the right eye turned down (right hypophoria).

(*e*) Still a fifth type exists, as in the following case. When the left eye was covered there was no hyperphoria. When the right was covered it deviated downward; in other words, right hypophoria developed. It would seem in this case that the term hypophoria is more suitable than hyperphoria.

In cases of this type it seems to make little difference in the kind and degree of lateral deviation whether the right or the left eye is covered. Thus, when the left eye of one patient was covered 4 degrees of left hyperphoria developed with 8 degrees of exophoria. When the right eye was covered right hyperphoria of 6 degrees and exophoria of 10 degrees developed; that is to say, with a difference of 10 degrees in the vertical position between the two eyes with the muscles relaxed there was only a variation of 2 degrees in the lateral deviation.

5. In addition to lateral and vertical deviations, the condition known as cyclophoria (rotation on the anteroposterior axis) requires some notice. This may be limited to one eye or may be greater in one eye than in the other and may vary from 0 to 10 degrees. This is observable in making the tests for hyperphoria with the Maddox rod and is more obvious after occlusion than before. It has in common with the other deviations a great variability in degree.

Two observations emerge from these groups of cases. First, hyperphorias are just about as common as exophorias—a fact not without significance. I am referring only, of course, to postocclusion findings.

Thus, of the first 700 cases a lateral deviation was found in 91 per cent (exophoria in 78 per cent and esophoria in 12 per cent) with or without vertical deviation. Hyperphoria, on the other hand, was present in 84 per cent, with or without lateral deviation. There seems to be no reason to seek different causes for the two groups (lateral and vertical).

PRISM ABDUCTION

In association with the phorias there are certain other phenomena which come up for consideration. What, for instance, is prism abduction? There are two possible departures in the horizontal plane from the parallel position the visual lines assume when the eyes are adjusted for infinity, that is, convergence and divergence. The reason for convergence is easily understood. It is a response to the need for binocular single vision and therefore depth perception for objects, especially at the near point. In other words, it is a definitely purposive phenomenon. On the other hand, divergence from parallelism is quite purposeless. Any useful purpose served by it is unthinkable. It may be, however, a vestige or rudiment of an earlier stage when the eyes could be used simultaneously in the interest of circumferential vision. As a matter of fact, it no longer exists in man under natural conditions and can be brought about only by placing prisms, base in, in front of the eyes. Prism abduction can therefore be regarded as a vestige of a function originally purposive and now no longer so. A case occasionally occurs in which the power of an active divergence still persists. This and prism abduction are evidences of the existence of a divergence center; so also with sursumduction and deorsumduction. They serve no useful purpose. In whatever position the head is placed single vision requires that the visual lines remain in that plane of the head in which the eyes converge for fixation of objects at different distances. If one visual line departs from that plane the slightest degree, confusion or diplopia must arise. These activities must be regarded as nonpurposive and therefore vestigial. Some animals representing an earlier evolutionary period, such as the chameleon, have the power of moving the visual lines into different planes.

Of this curious reptile, Gadow, the "Encyclopedia Britannica" stated:

> The right and left eyes are incessantly moved separately from each other and literally in every direction, up and down, forwards and straight backwards, producing the most terrible squinting. [And yet] chameleons alone, of all reptiles, can focus their eyes on one spot, and conformably they alone possess a retinal macula centralis or spot of acutest binocular vision.

In keeping with their rudimentary nature, these phenomena (prism abduction and sursumduction) vary much in degree.

CONCLUSIONS

The phorias and ductions can all be accounted for on an evolutionary basis and on no other conceivable single hypothesis. The idea that many of the vertical deviations can be attributed to paresis is without sufficient justification. They occur in about the same frequency as, and often in association with, lateral deviations, and there seems to be no reason for assigning different causes to the two. Thus, in those cases in which the facts are consistent with the theory of paresis, they are equally well explained by assuming normal variation to be the cause.

The findings of the occlusion test furnish no reason for assuming the dependence of one form of deviation on another, except in some cases of manifest or pseudo-esophoria in which the effort to overcome hyperphoria calls on the third nerve for excessive activity, with resulting convergence. Manifest esophoria should always be looked on with suspicion.

The hypothesis put forward in this paper has the advantage of bringing into coherent relationship with one another a number of otherwise isolated phenomena.

Whether it proves to be valid or not, it certainly tends to clarify one's mind, give a definite point of departure and stimulate thought. For instance, if the condition described under the first type of hyperphoria is accepted as representing a prebinocular vision period and orthophoria is accepted as representing the culmination of the evolutionary process, as seems to be tacitly granted, what do the intermediate deviations stand for? Do they not represent a vast series of intermediate evolutionary periods? The theory also carries with it some suggestion as to the best method of dealing with the conditions found. For instance, in cases of the first type of hyperphoria, in which the deviation shows on one side only, it would seem rational to place the correcting prism before the hyperphoric eye. In cases in which there is the hyperphoria on one side and hypophoria of equal degree on the other, the prismatic correction should be divided equally between the two eyes. In cases in which the deviation is definitely of the hypophoric type, the correction should be placed before the hypophoric eye.

RETAINED INTRA-OCULAR FOREIGN BODIES

A CLINICAL STUDY, WITH A REVIEW OF THREE HUNDRED CASES

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OMAHA

In this communication it is not proposed to enter into a lengthy discussion of the various problems encountered in the diagnosis and management of intra-ocular foreign bodies; the intention is rather to analyze the histories in a series of 300 cases of retained foreign bodies in the globe. A review of the recent literature was made in an effort to clarify and evaluate the present trends and more generally accepted methods of treatment. As the study proceeded, it became more and more evident that this topic is still in an amazing state of confusion and more or less resolves itself into a personal equation, the solution of which depends for the most part on the individual preference or whim of the author consulted.

One notes, however, the beginning of a more conservative approach; especially is this attitude in evidence among those oculists having the greatest experience. There is sufficient evidence accumulated over the years that the mere presence of a foreign body in the globe is no occasion for haste, excitement and ill advised removal. The analysis of this series of 300 cases supports that contention and has brought to light a number of interesting facts in sharp contrast to the prevailing opinion of ten or fifteen years ago.

No attempt is here made to formulate any set rule, nor does it appear seemly or profitable to the scope of this report to digress into theoretical discussions of the individual differences of opinion existing in this field, a debate that defeats its own purpose by repetition and one that can be settled only by time and recorded observation.

Once the diagnosis and definite localization of a foreign body within the eye have been made, the problem over which most of the division of opinion still exists is the question dealing with the route of extraction, whether anterior or posterior, and which of these is best suited with reference to the site of the foreign body. Obviously, no one route can be employed dogmatically to the exclusion of the other. My experi-

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ence has impressed on me another precept of equal importance and one that a number of years ago would have been denounced had any one had the temerity to advance it. All too frequently heroic methods have been employed to remove a foreign body on the assumption that its retention would sooner or later result in complete loss of vision or actual loss of the involved eye, with a probability of sympathetic ophthalmia occurring in the other. This attitude has in many cases actually precipitated a tragedy instead of averting one. It must therefore be kept in mind constantly that the question of which route of extraction to use may not always be the major consideration. One may be better justified under certain circumstances to allow the foreign body to remain in place. It is axiomatic that the removal of a foreign body from the interior of the globe does not insure saving either the eye or its vision. The prognosis in any event is always a serious one, and the oculist, though not always able to restore or save function, is under the moral restraint never to add insult to injury and aggravate an already trying condition by indulging in meddlesome interference.

ANALYSIS OF CASES

In reviewing the histories of these 300 cases it was interesting to note that subjective symptoms were not always in evidence or conclusive. In spite of the sensitivity of the cornea and conjunctiva, paradoxically, a number of patients were totally unaware that any accident had occurred, the entry of the foreign body having been quite painless. Four per cent of the patients gave no history of injury. In 3 cases the diagnosis was made many weeks later on the basis of an existing siderosis. One patient was treated elsewhere and referred to me because of an intractable iritis. The corneal microscope revealed a small flake of steel in the lens. In 2 cases in which the patient made no unusual complaints beyond that of so-called "eyestrain," the routine examination with the ophthalmoscope detected small scars in the cornea with corresponding minute holes in the iris, and on more detailed examination foreign bodies were found in the peripheral portion of the lens. In both instances vision was normal. Three other patients complained only of beginning and slight visual failure; all 3 had beginning traumatic cataracts from foreign body inclusion. Not one of these could recall any injury to the eye. One other patient had been treated for absolute glaucoma, but after enucleation of the eye a piece of steel was found lodged in the retina. I wish to emphasize, therefore, that while a careful inquiry into any possible trauma should never be omitted from the routine history, yet at the same time too much credence should not be placed on the patient's negative statement.

As to the methods used for diagnosis, little need be said here beyond mentioning the systematic use of the ophthalmoscope and the corneal microscope and the routine taking of roentgenograms in all cases in which an intra-ocular foreign body is suspected or even remotely considered to exist. I feel that the use of the magnet should never be resorted to as a diagnostic aid until all other methods have been exhausted and the roentgenographic report is inconclusive. Roentgenograms were obtained in all 300 cases, and it was possible to demonstrate and acurately localize the foreign body in 97.5 per cent of the cases. In the remaining 2.5 per cent, small foreign bodies were subsequently extracted with the magnet, the roentgenographic report being negative.

As to the incidence of penetrating bodies, I found that in this series the majority were noted in males engaged in the usual industrial occupations. Of the 300 patients, all except 6 were males, 60 per cent of whom were between 20 and 40 years of age. The right eye was injured in 133 patients, the left eye in 162 and both eyes simultaneously in 5.

As to the method of extraction, the anterior route was used in 140 cases and the posterior route in 39, leaving 121 cases in which other methods of treatment were employed. Of these 121 cases, there were 101 in which the foreign body was retained in some portion of the globe, the time element varying from one month to thirty-five years. In the cases in which the extraction was done with a magnet, the following principles were employed in the majority of instances: In those cases in which healing had not taken place, if the foreign body had entered through the cornea and passed through the lens into the vitreous chamber, the wound of entry still being open, and the fragment of steel was not too large, it was removed through the original site of entrance. If, on the other hand, the fragment was of such a size that its removal by the anterior route might produce further harm to the anterior structures of the eyeball, the foreign body was removed by a posterior scleral incision. If the foreign body had entered through the sclera, obviously its removal was effected through the sclera. In cases in which healing had taken place, the original wound having closed by solid union, the mode of extraction of the foreign body fell into one of two routes, either anterior or posterior, according to the location of the foreign body.

In an analysis of the 140 cases in which the anterior route was used it was found that a foreign body was removed from the anterior chamber in 20. Fifteen of the patients retained good vision, of 20/30 or better, and cataract developed in 3 (who were not operated on); of the remaining 2, who lost their vision permanently, 1 required enucleation because of panophthalmitis, and uveitis and phthisis bulbi developed in the other. There were 19 cases in which the foreign body was located

and removed from the iris. Fifteen of the patients retained good vision. Cataracts developed in 4, only 1 of whom was operated on. In 28 cases the foreign body was located and removed from the lens. Three of the patients retained good vision without glasses, although peripheral opacities were present. Cataracts developed in 21, 12 of whom were operated on, with subsequent good corrected vision. In the cases in which the foreign body was removed from the lens, only 3 of the patients had complete loss of vision. Severe uveitis developed in all 3 after removal of the foreign body.

Thus it will be noted that in the 67 cases in which the foreign body was removed by the anterior route from the anterior segment of the globe, 33 of the patients, or almost 50 per cent, retained good vision without correction, and the remainder were rendered industrially blind in the injured eye. Only 9 per cent lost their vision completely and permanently, owing to enucleation, severe uveitis or retinal detachment.

There were 73 cases in which the foreign body was located in the posterior segment of the globe, and its removal was effected by the anterior route. In 1 of these it was found in the ciliary region. A hemorrhage occurred in the vitreous in this case, with complete loss of light perception. In 66 of the 73 cases the foreign body was located in the vitreous. After extraction, 8 of the patients retained good vision without glasses; cataracts developed in 23, 5 of whom were operated on, with good corrected vision in all. In 34 cases vision was permanently lost, and in 1 the outcome was unknown. Retinal detachment was the cause of loss of vision in 16. Fourteen of the patients required enucleation because of panophthalmitis or uveitis. In 2, the vision was lost because of the failure of an operation for cataract. Glaucoma developed in 1 and retinitis proliferans in 1. There were 6 cases in which the foreign body was found and removed from the retina by the anterior route. Only 2 of the patients retained good vision, and cataract developed in 2, 1 of whom was successfully operated on.

To the casual reader this statistical survey may seem somewhat lengthy. However, in summarizing the foregoing figures it should be of interest to note that when the foreign body was located in the anterior segment of the globe and removed by the anterior route, good uncorrected vision was retained in 50 per cent of patients. Only 9 per cent lost the vision in the injured eye completely and permanently. But when the foreign body was removed by the anterior route from the posterior segment of the eye, good vision was retained in only 13 per cent of the patients, and in 50 per cent vision was entirely and permanently lost. It would seem obvious, therefore, that the anterior route of extraction for a foreign body located in the posterior segment is not the method of election.

This statement is sustained by analyzing the cases in which the foreign body was located in the posterior segment and was removed by the posterior route. There were 39 of these; in 7 the foreign body was in the ciliary region, in 27 it was in the vitreous and in 5 it was in the retina. Four of the patients in the first group retained good vision without glasses after removal of the foreign body. Total retinal detachment developed in 1. The results in 2 patients were complicated by cataracts, which were not operated on. Twelve, or 45 per cent, of the patients in the second group retained good vision after removal of the foreign body; cataract developed in 5, and 9, or 33 per cent, lost their vision because of detachment of the retina. There remains 1 case in which the outcome was unknown. Two of the patients in the third group retained excellent vision without glasses, but 3 lost sight in the injured eye because of retinal detachment, uveitis and macular degeneration, respectively. Thus it will be seen that when the posterior route was used for the extraction of a foreign body in the posterior segment, 49 per cent of the patients obtained good vision without glasses, and 33 per cent lost their vision entirely.

In a final summary as applied to these two routes of extraction, my figures indicate that 50 per cent of the patients with a foreign body located in the anterior segment of the globe and removed by the anterior route retained good vision without glasses, 9 per cent lost the vision in the injured eye permanently and the remainder were rendered industrially blind. Only 13 per cent of persons with a foreign body located in the posterior segment and removed by the anterior route obtained good uncorrected vision, and 50 per cent lost permanently the vision in the injured eye. Forty-nine per cent of the patients with a foreign body located in the posterior segment and removed by the posterior route obtained good vision, and 33 per cent lost the vision in the injured eye entirely. The inference is obvious. It may be stated that in none of the cases in which extraction was done by the posterior route were Walker pins used to prevent a possible occurrence of retinal detachment.

As stated in the earlier part of this report, there were 101 cases in this series of 300 in which the intra-ocular foreign body was not removed from the globe at the time of the accident but was retained within some portion of the eye, the time element varying from one month to thirty-five years. For purposes of completeness, a statistical survey of the histories was also made, the analysis of which has made me by conclusion less willing to accept certain popular tenets of the past in regard to the advisability of removing every foreign body whenever diagnosed.

Three patients retained copper in the anterior chamber for six months, two years and eight years, respectively. In all 3 the foreign body was removed with forceps. In 2 the vision remained good, but severe uveitis developed in the third after removal of the copper particle, and six years later the patient was able to count fingers only.

Six patients had retained the foreign body in the iris for from seven months to four years when first examined. In 1 patient a foreign body of either brass or copper was lodged in the iris for seven months. Vision was 20/30 and the patient refused to have the foreign body removed. In 4 other patients the foreign body was steel and was removed, with preservation of good vision. Siderosis, which was quite

TABLE 1.—*End-Results in Twenty-Six Cases in Which the Foreign Body Was Retained in the Vitreous for a Period of from One Month to Thirty-Five Years* *

Case No.	Type of Foreign Body	Period Retained	End-Results
1	Steel (small)	1 mo.	Removed by anterior route; 2 mo. later, severe uveitis; enucleation
2	Copper	2 mo.	Retinal detachment; later, uveitis; enucleation
3	Steel	2½ mo.	Removed by posterior route; retinal detachment; no perception of light
4	Steel	2 mo.	Removed by anterior route; 2 yr. later, cataract; projection good
5	Lead	2 mo.	Uveitis; enucleation advised
6	Steel	3 mo.	Removal by anterior route followed by uveitis, sympathetic irritation; enucleation
7	Brass	6 mo.	Uveitis followed by detachment of the retina
8	Steel	11 mo.	Chronic uveitis; enucleation
9	Steel	1 yr.	Chronic uveitis; enucleation
10	Lead	1½ yr.	Retinal detachment; eye quiet
11	Steel	1½ yr.	Removed by anterior route; late, operation for cataract; detached retina
12	Steel	2 yr.	Removed by anterior route; detached retina
13	Steel	2 yr.	Uveitis; enucleation
14	Steel	2 yr.	Removed by anterior route; 5 yr. later, glaucoma; enucleation
15	Steel	2½ yr.	Removed by anterior route; 1 yr. later, glaucoma; trephine operation
16	Steel	2½ yr.	Glaucoma; enucleation advised
17	Steel	4 yr.	Retinal detachment
18	Steel	4½ yr.	Removal by posterior route followed by severe uveitis, sympathetic irritation; enucleation
19	Steel	7 yr.	Uveitis; enucleation
20	Steel	8 yr.	Uveitis; enucleation
21	Steel	9 yr.	Detached retina
22	Steel	10 yr.	Glaucoma; enucleation advised
23	Steel	10 yr.	Glaucoma; enucleation
24	Steel	16 yr.	Uveitis; enucleation
25	Steel	32 yr.	Cataract; no perception of light; no trouble
26	Steel	35 yr.	Uveitis; enucleation

* In summary, there was permanent loss of vision in 25 cases, in 1 of which operation for cataract might have been done. Enucleation was done in 13 cases and was advised in 3 others. Detachment of the retina developed in 8 cases and glaucoma in 3 others. The foreign body was removed by the anterior route in 7 cases, after retention of the steel for the period of from one month to two years, and by a scleral incision in 2 cases, with poor results in all.

extensive in all 4, disappeared completely a year after the extraction of the foreign body. One patient retained a flake of nonmagnetic metal in the iris for four years, and glaucoma developed, which was relieved by a trephining operation.

Of the 14 patients with a foreign body lodged in the lens, 4 lost their vision permanently. A piece of steel was removed from the lens of each of 2 patients two months after injury, and in each severe uveitis developed, which ended with complete blindness in the injured eyes. Glaucoma developed in 1 patient after retention of a piece of copper

in the lens for four years. The eye was enucleated. Retinal detachment developed in the other patient after an operation for cataract. In this

TABLE 2.—*End-Results in Forty-Nine Cases in Which the Foreign Body Was Retained Either in the Retina or in the Sclera for a Period of One Month to Twenty-Five Years* *

Case No.	Type of Foreign Body	Period Retained	End-Results
1	Steel	1 mo.	Retinal detachment; results with magnet negative
2	Steel	2 mo.	Removed by anterior route; vision 20/20 2 mo. later
3	Steel	2 mo.	Magnet failed; removed by posterior route; severe iritis; enucleation
4	Copper	2 mo.	Copper in each eye; each eye blind
5	Steel	3 mo.	Removed by posterior route; 2 yr. later, vision 20/20
6	Steel	3 mo.	Uveitis; enucleation
7	Brass	3 mo.	Outcome unknown; no perception of light
8	Steel	6 mo.	Vision 20/20; removal by posterior route followed by severe uveitis; vision 2/200 6 mo. later
9	Steel	6 mo.	Removed by anterior route; 5 yr. later, vision 20/30
10	Steel	6 mo.	Nonmagnetic; observation for 2 yr.; vision 20/100
11	Steel	6 mo.	Removed by anterior route; detached retina
12	Steel	9 mo.	Extraction failed by posterior route; detached retina
13	Steel	1 yr.	Operation for cataract; retinal detachment
14	Steel	1 yr.	Vision 20/20; magnet not tried
15	Steel	1 yr.	Vision 20/50; magnet not tried
16	Steel	1 yr.	Operation for cataract; retinal detachment
17	Steel	1 yr.	Cataract; no operation; projection good
18	Steel	1 yr.	Cataract; no operation; projection good
19	Steel	1 yr.	Cataract; no operation; projection good
20	Steel	1 yr.	Vision 20/30; removed by posterior route; severe uveitis developed
21	Steel	2 yr.	Vision 20/15; magnet not tried
22	Steel	2 yr.	Removed by anterior route; severe uveitis; enucleation
23	Steel	2 yr.	Vision 20/40; magnet not tried
24	Steel	2 yr.	Vision 20/20; magnet not tried
25	Steel	2 yr.	Severe uveitis; enucleation
26	Steel	2 yr.	Operation for cataract; retinitis proliferans; vision 8/200
27	Steel	2 yr.	Severe uveitis; enucleation
28	Steel	2 yr.	Operation for cataract followed by severe uveitis and phthisis
29	Steel	3 yr.	Vision 20/40
30	Steel	3 yr.	Cataract; projection good; no operation
31	Steel	3 yr.	Glaucoma; enucleation
32	Steel	4 yr.	Vision of 20/40 for 3 yr.; retinal detachment
33	Steel	4 yr.	Retinal detachment
34	Steel	5 yr.	Vision 20/200; cataract
35	Steel	6 yr.	Operation for cataract; vision 20/70 with correction
36	Steel	8 yr.	Retinal detachment
37	Steel	8 yr.	Vision 20/30
38	Steel	9 yr.	Retinal detachment
39	Steel	9 yr.	Cataract; no operation; projection good
40	Steel	10 yr.	Vision 20/20
41	Steel	11 yr.	Cataract; good projection; no operation
42	Steel	12 yr.	Retinal detachment
43	Steel	12 yr.	Cataract; no operation; projection good
44	Steel	16 yr.	Vision 20/30
45	Steel	20 yr.	Vision of 20/70 for 12 yr.; finally iritis and glaucoma; enucleation
46	Steel	21 yr.	Glaucoma; trephine operation; no perception of light
47	Steel	15 yr.	Operation for cataract; vision 20/25 with correction
48	Brass	16 yr.	Retinal detachment
49	Steel	25 yr.	Retinal detachment

* In summary, there was permanent loss of vision in one eye in 26 cases, in only 7 of which it was due to enucleation. Retinal detachment occurred in 12 cases and glaucoma in 3. Good vision was retained in the injured eye in 13 cases (the foreign body being retained from two months to sixteen years), and in only 4 of these had the foreign body been removed. The foreign body was removed in only 7 of the 49 cases, in 3 with poor results. Cataract developed in 10 cases, in 2 of which operation was performed with good results.

case a nonmagnetic piece of metal was retained in the lens for a period of five years. Of the 7 patients in whom cataract developed, 5 were

operated on, and vision improved to 20/30 or better with glasses. Of course these eyes are considered industrially blind. Only 3 of the 14 patients maintained good uncorrected vision, the foreign body being located in the peripheral portion of the lens. One was a small splinter of glass which had been retained for four years.

Of the 3 cases in which the foreign body was lodged near the ciliary region, removal in 1 was done by the posterior route two months after the injury. Vision was 20/30 three years later. In the other 2 cases the foreign body was nonmagnetic. Severe uveitis developed in the eye of 1 patient two years after injury, and retinal detachment developed in the other patient eight years after the retention of the foreign body.

Table 1 shows the end-results in 26 cases in which the foreign body was located in the vitreous for a period of from one month to thirty-five years. Table 2 shows end-results in 49 cases in which the foreign body was retained either in the retina or in the sclera for from one month to twenty-five years.

In this series of 101 cases there was a total and permanent loss in vision in 60 eyes. Twenty-one of these eyes were enucleated, and enucleation of 3 others was advised. Good vision was maintained in 22 cases, in 9 of which the foreign body was removed—in 1 from the anterior chamber, in 3 from the iris, in 4 from the retina and in 1 from the ciliary region.

In the other 13 cases the foreign body was not removed but was retained in the following structures of the eyeball:

Location	Period of Retention	Vision
Iris	7 mo.	20/30
Lens	1 yr.	20/20
Lens	4 yr.	20/30
Lens	8 yr.	20/30
Retina	1 yr.	20/20
Retina	1 yr.	20/50
Retina	2 yr.	20/15
Retina	2 yr.	20/20
Retina	3 yr.	20/40
Retina	8 yr.	20/30
Retina	10 yr.	20/20
Retina	16 yr.	20/30

The retention of a foreign body in the vitreous chamber always gave rise to complications which led to ultimate destruction of vision.

In not a single case did the retention of a foreign body within the eye produce a sympathetic inflammation, but its removal in 2 instances did produce a sympathetic irritation.

A study of these 101 cases brings out one striking feature, perhaps the most significant of all, and that is the regrettable fact that in too many instances in which the eye and vision were good and in which the foreign body was removed, not only was the visual acuity reduced immediately but in much too high a number of cases complications of such serious nature developed that enucleation of the eye became necessary. I feel strongly that these complications were induced in quiescent eyes by nonindicated extraction of the foreign body.

Those who practice ophthalmic surgery must all be agreed that from a psychologic standpoint the enucleation of an eye is to a patient not only an operation of considerable magnitude but one approached by him with a trepidation amounting to terror, and justifiably so. For in many instances, especially in industry, the patient loses his ability to earn a living and is reduced to a state of economic dependency. All efforts, therefore, should be directed toward saving him from this calamity. Naturally many eyes are beyond salvation from the beginning, but I am impressed with the number of eyes in the present series for which enucleation became necessary many weeks or months after the original injury, which during that time were actually serviceable eyes.

Of the 300 cases, there were 67, or 22 per cent, in which enucleation was necessary. In 35 cases removal of the globe was necessary a few days after the accident as a result of panophthalmitis. The nature of the foreign body furnishes no clue as to cause of the infection. Possibly poor first aid care at the scene of the accident may explain this phenomena in part. I note, however, that in all except 1 of these cases the foreign body was lodged in the vitreous chamber. Possibly this is of some significance. In 22 of the 67 cases violent uveitis developed subsequent to the removal of the steel particle, and in the greater number of these cases the removal of the foreign body was attempted from months to years after the accident, during which time the patient had a good cosmetic eye, even though perhaps indifferent vision. In 7 cases enucleation was required, because of glaucoma. This, I feel, was unavoidable, as the eyes were blind and extremely painful. In 3 cases enucleation was required because of double perforations, to which was superimposed a panophthalmitis. Not a single enucleation was done because of sympathetic inflammation. This point I feel is certainly worth stressing. The conception that the retention of a foreign body within the eyeball will give rise to sympathetic ophthalmia seems to be founded on a false premise. The only case of this sort that occurred in the present series was that of a boy 12 years old, in whom sympathetic inflammation developed three months after a small flake of steel had been removed from the iris. Subsequently and with proper treatment he recovered vision of 20/20 in each eye.

A study of the cases in which a retinal detachment occurred brings to light some interesting facts.

In 41 cases in which retinal detachment occurred, the foreign body was located in the vitreous, and in 23 of these the removal of the steel was effected by the magnet, in 15 cases by the anterior route and in 8 by the posterior method. In the 18 other cases the metal which was retained in the vitreous was of the nonmagnetic variety.

In 9 cases in which retinal detachment occurred, the foreign body had its position in the retina. In 2 of these cases retinal detachment was noticed before the foreign body was removed by the magnet. In 1 instance a small piece of steel was retained in the retina for six months and gave no trouble. However, after removal of the foreign body there occurred severe uveitis followed by total detachment of the retina. In 1 other case the steel was removed by the anterior route, with resulting detachment. In the other 5 cases the metal was retained in the retina for periods of from one month to twenty-five years.

I feel that the most important causes of retinal detachment in this series of cases were an inflammatory retraction of the vitreous, producing bands of adhesions, retinal tears and postretinal hemorrhages and exudates.

In 17 cases (of the 300) the foreign body entered the cornea and perforated the sclera, causing a double perforation. In 3 of these panophthalmitis developed, and the eyes had to be enucleated. In the other 14, only 4 of the patients had useful vision, 20/50 or better, four months after the accident. The other 10 patients were observed over a period of from one to eight years, but all were rendered industrially blind in the injured eye either by cataract or by retinal detachment.

Of the cases in which the foreign bodies were of the nonmagnetic variety, copper was present in 13, brass in 5, lead in 5, glass in 2 and stone in 1. In analyzing these cases, it was found that a foreign body could be retained in the anterior chamber of the iris for a number of years with preservation of perfect vision. However, when it was retained in the vitreous the eye was lost in all cases, either by uveitis or by panophthalmitis. In all 5 cases in which the intra-ocular foreign body was brass enucleation was necessary. The same applied to lead, glass and stone, when the particle was in the vitreous. No attempt was made in this series to remove nonmagnetic foreign bodies if they were located in the posterior segment. It seems apparent, therefore, when one is dealing with nonmagnetic foreign bodies, that one located in the anterior segment may be tolerated for over a period of years without producing harm, but one lodged in the vitreous invariably produces disorganization of the structures of the globe. Even though there may have been little irritation for a considerable period, iridocyclitis and

loss of the eye were the final results in the cases under consideration. Foreign bodies lodged in the retina or in the retina and sclera were tolerated about as well as those lodged in the anterior segment of the globe.

Before concluding, a word seems in order apropos of the treatment after extraction. The postoperative care is of utmost importance. It is difficult to impress the necessity of this on the average laborer. A man who otherwise feels well finds it hard to reconcile himself to the confinement of absolute rest in bed for a period of from ten to fourteen days after the removal of a small piece of steel from the posterior segment of his eye. He not only regrets the loss of time at work but is likely to consider the entire procedure a trivial one. However, experience has taught that such precautions are well worth while and should be insisted on in every case, no matter how simple the operation of extraction might have been. More recently I have used electro-coagulating pins for all extractions by the posterior route. Three or four pins are placed into the sclera as near to the foreign body as possible, the same technic being used as in the operation for retinal detachment. These pins are placed in position before the sclera is opened and the foreign body removed. I believe that detachment of the retina is reduced to a minimum by this precautionary measure.

CONCLUSIONS

This study has brought my attention to the following points:

While an inquiry into the history of an accident should always be made of all patients coming to the oculist for examination, a negative subjective history is no criterion that none occurred.

It is of paramount importance to have accurate localization before extraction is attempted, and this can be obtained in all but a few exceptional cases by roentgenographic studies.

Rarely should the magnet be used for the mere detection of a foreign body.

A foreign body located in the anterior segment is best removed by the anterior route, and one in the posterior segment, through the scleral route. Electrocoagulating pins should be used in all cases in which extraction is done by the posterior route. It is best to remove a foreign body from the interior of the eye in cases of recent injury.

The view that the retention of a foreign body in one eye will cause a sympathetic inflammation in the other eye is not sustained by my observations. On the contrary, I have found that sympathetic irritation developed only in cases in which ill advised efforts at removal were utilized.

Preservation of useful vision or of the eyeball is possible perhaps for the entire lifetime of the patient in spite of the retention of a foreign

body in the posterior segment of the globe. One may assume that such a patient could not have fared better had intervention been adopted.

The knowledge that a foreign body within the eye may be tolerated for prolonged periods of time is worthy of consideration when one is deciding on the management of such cases, and conservative treatment is more often indicated than recommended by the majority of writers on the subject. However, the patient must be under the observation and care of a competent oculist for a period of years.

TECHNIC OF GONIOTOMY

OTTO BARKAN, M.D.
SAN FRANCISCO

Goniotomy, or the opening of Schlemm's canal under direct vision, is an operation for the relief of that form of chronic glaucoma which is characterized by an open angle and normal depth of the anterior chamber.

The success of the operation [1] depends on two essential factors: (1) the proper selection of suitable cases by a preoperative biomicroscopic examination of the angle of the anterior chamber and (2) the use of a specially made contact glass, the prismatic action of which provides a magnified picture of the inside of the angle of the anterior chamber, so that the surgeon is able under direct vision to guide his knife from the temporal limbus across the anterior chamber until it strikes the trabeculum on the opposite side. A similar approach to the angle was used by De Vincentiis in 1892, but his procedure was a blind one, since it was impossible to see where the knife was going. Moreover, in the absence of a biomicroscopic (gonioscopic) method, it was impossible to determine which cases were suitable. The operation was later abandoned.

PRELIMINARY PROCEDURES

The surgical contact glass (fig. 1) [2] should be tried on the patient's eye previous to the day of operation in order to insure its adaptability to the individual case. The standard model will be found to be satisfactory for most cases, but occasionally an exceptionally narrow palpebral fissure demands the use of a smaller model. The lids are separated with a speculum or by means of lid sutures in cases in which the palpebral fissure is narrow. Canthotomy should be avoided, for a trace of blood in the conjunctival sac is likely to disturb visibility by mingling with the fluid between the cornea and the contact glass. As direct vision is the essence of this procedure, the thought of maintaining visibility must always remain foremost in the surgeon's mind. Everything should be ready before local anesthesia with pontocaine (paranormobutylaminobenzoyldimethylaminoethanol) hydrochloride is started. Anesthesia should not be prolonged beyond the few minutes that are

1. Barkan, Otto: A New Operation for Chronic Glaucoma, Tr. Sect. Ophth., A. M. A., 1936, p. 244; A New Operation for Chronic Glaucoma: Restoration of Physiological Function by Opening Schlemm's Canal Under Direct Magnified Vision, Am. J. Ophth. **19**:951-966 (Nov.) 1936.

2. The surgical contact glass is now available from Carl Zeiss, Inc., New York.

necessary to induce it. Once the glass is applied, the steps of the operation should follow in rapid succession in order to avoid a disturbance of visibility due to haze of the corneal epithelium, the formation of folds in Descemet's membrane (which may occur in eyes with low tension after prolonged contact with the glass) or the entrance of air bubbles or blood between the contact glass and the cornea.

TECHNIC OF OPERATION

1. The pupil should be miotic, the eye having been well treated with physostigmine before operation.

2. Local preparation of the eye is the same as for any intra-ocular operation, except that the lashes of only the outer third of the lids need be clipped. Ointment should not be used, in order to avoid the formation of an oily film on the glass.

3. Akinesis is secured in the usual way.

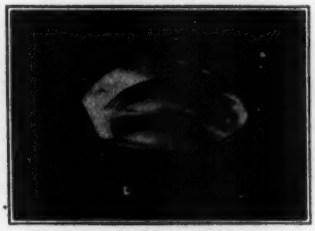

Fig. 1.—Surgical contact glass.

4. The height of the operating table and of the eye of the patient is so adjusted that the surgeon, who stands at the side of the patient's head, may conveniently transfer his gaze from the limbus to above the temporal edge of the contact glass and to the anterior chamber by means of slight movement of his head or body. If the surgeon prefers to sit on a stool, its height must be adjusted relative to the eye of the patient so that the surgeon may transfer his gaze by means of a slight movement of his head.

5. Local anesthesia is obtained by means of instillation of drops of 1 per cent pontocaine hydrochloride. An applicator saturated with 1 per cent pontocaine hydrochloride may advantageously be held on the nasal limbus for five seconds. A drop of 1:1,000 solution of epinephrine given with the last drop of pontocaine hydrochloride increases the corneal luster.

6. Immediately after this last drop, everything being in readiness, the eye is fixed with a forceps, and the surgical contact glass is applied in the following manner:

In the case of the right eye, both the patient's face and his gaze are rotated to his left. In the case of the left eye, the direction is

reversed. After the conjunctival sac is freed of mucus or débris that may disturb the visibility, the surgeon grasps the limbus at 10 o'clock with a small Elschnig forceps, with a lock, held in his left hand. The forceps is locked and is permitted to hang from the limbus. It will be found that fixation is best done before rather than after the application of the glass. If, however, the surgeon prefers to apply the glass first, in order to prevent the entrance of air through dimpling of the sclera he must exert a little extra pressure on the glass with an applicator held in his right hand while the left hand grasps the limbus with the forceps. After the surgical contact glass is placed on the eye, physiologic solution of sodium chloride is injected under the temporal edges of the glass by means of a 1 cc. Luer syringe with a small curved cannula.

With the head still maintained in this position, the patient is directed to rotate his gaze slowly from the left straight upward, The eye with the contact glass on it is now in a position of abduction relative to the head and looks straight at the ceiling. The assistant, who stands behind

Fig. 2.—A bident.

the head, keeps the glass in position by means of a double-pronged probe, a bident (fig. 2), which is held in the right hand without exerting undue pressure and in such a manner as to leave a crescent of the temporal limbus exposed. Such pressure as there is must be in *the direction of the optic axis of the globe* in order to avoid the entrance of air under the glass. As soon as fixation is established and the glass applied, care must be taken to avoid pressure with the forceps. Traction rather than pressure should be exerted. The surgeon then (1) dries the temporal limbus with the tip of an applicator, (2) applies a solution of iodine at the intended point of puncture with an applicator and (3) punctures at this point (just scleral to the corneoscleral border) with the goniotomy knife. A second assistant or nurse has meanwhile guided the narrow beam of a hand lamp [3] from across the bridge of the patient's nose to transilluminate the nasal portion of the limbus and the corresponding region of the angle of the anterior chamber. The surgeon, who stands in a comfortable position at the side of the patient's head, the table having been previously adjusted to the proper height, guides

3. An improved focal illuminating lamp designed for this purpose will be available in the near future. The goniotomy knife can be obtained from V. Mueller & Co., Chicago.

the knife (fig. 3) [4] across the chamber and into the angle between its lower and its nasal third in the right eye and between its upper and its nasal third in the left eye by direct vision through the glass. When the blade reaches the magnified angle, its point is inserted into that portion of the trabeculum which covers Schlemm's canal and the incision is continued counterclockwise for several millimeters along this line (about one fourth of the circumference). For the right eye the surgeon stands to the right of and behind the patient's head; for the left eye, he stands at the patient's left shoulder. If the incision appears insufficient either in extent or in depth, the knife may be rotated on its axis and the incision repeated in the reverse direction. The knife is then quickly removed without loss of aqueous, care being taken to avoid enlarging the puncture

Fig. 3.—Goniotomy, showing the knife crossing the anterior chamber.

wound at the limbus by pressing slightly against the back of the blade during removal. There may be a slight amount of bleeding into the anterior chamber from the intrascleral plexus along the line of incision, but this is absorbed within a few hours.

In traversing the chamber, the knife must always cross the optic axis. The diameter of the arc that it describes after the trabeculum is engaged will then be greater than the diameter of the circumference of the limbus, and thus the point of the knife remains engaged during the incision. If the knife does not cross the optic axis, the opposite holds true; in describing a smaller arc than that of the limbus, the point of the knife soon becomes disengaged, and too small an incision is made.

Owing apparently to the varying topographic relations of the angle and of Schlemm's canal, one cannot always be certain of opening the canal. That this may be accomplished with a fair degree of certainty and

4. Figure 3 illustrates an earlier model of the contact glass and probe than is now being used.

exactitude is shown by the results of postoperative biomicroscopic examination, which usually shows a single straight dehiscent slit of the trabeculum over Schlemm's canal associated with normalization of intra-ocular pressure. What appears to be the glistening white inner lining of the outer wall of Schlemm's canal is visible through this longitudinal bisection of its inner wall. The sclerocorneal trabeculum may be either bisected or torn off, the operation constituting what may be called a trabeculotomy or trabeculectomy, respectively.

RELATION OF AMOUNT OF REDUCTION OF INCREASED INTRA-OCULAR PRESSURE TO EXTENT OF OPENING OF SCHLEMM'S CANAL

It is interesting to compare the great initial drop of intra-ocular pressure in one case, for instance from 120 to 42 (McLean), as the result of an extremely small opening of Schlemm's canal with the relatively small drop of pressure, from 50 to 22 (McLean), as the result of an extensive incision (from 3:30 to 7 o'clock on the limbus) in another case. This suggests that the degree of increase of intra-ocular pressure in "type 1 glaucoma" as in other varieties of glaucoma is largely a function of the vasomotor reflex of the particular patient and that it is in less direct relationship to the amount of mechanical block. As a matter of fact, in the first of the aforementioned cases pressure gradually returned to 70 in the course of eight months, showing that although the opening was sufficient to permit of temporary compensation via the vasomotor factor, it was insufficient to reestablish normal pressure permanently through an adequate outflow of intra-ocular fluid, as did the larger incision in the second case. Judging by this example and the experiences in other cases, it would appear that an incision to the extent of at least one fourth of the circumference is required for a permanently successful outcome. An incision that is too small is only partially effective, and it may also be that it is more likely to close in time, although one cannot be certain of this at present.

MAGNIFICATION

Magnification is obtained by wearing a binocular head loupe of desired strength. A 5 diopter head loupe when combined with the refractive power of the contact lens and the eye gives a total linear magnification of about 6 times. In selected cases in which higher magnification is desired the operation may be performed with a corneal microscope attached to the surgeon's head by means of a helmet. With this microsurgical technic, a magnification of 20 times may be obtained.[5]

5. Barkan, Otto: Micro-Surgery in Chronic Simple Glaucoma, California & West. Med. **48**:10-12 (Jan.) 1938.

ILLUMINATION

An assistant or nurse who stands on the opposite side of the patient's head directs the spotlight of a hand lamp at the nasal limbus, transilluminating it. While the incision is being made, the spotlight is directed so as to follow the point of the knife, which is visible to the assistant through the sclera as it moves along slitting the trabeculum. The surgeon can further direct the movement of the light by word of mouth. A second assistant or nurse stands beside the first one toward the foot of the patient and directs the light from a second lamp onto the eye for purposes of general illumination. This light can be removed or used at will during the procedure. It also serves as a reserve in case the first light should become obscured or get out of order. Thus constant illumination of the angle of the chamber is assured during the operation.

POSTOPERATIVE CARE

A patient is customarily hospitalized for two or three days, both eyes being occluded for the first twenty-four hours. The pupil of the eye on which operation was performed should be kept miotic with physostigmine for three weeks after the operation in order to prevent the root of the iris from being washed against or becoming adherent to the incision.

INDICATIONS

As has been suggested in a previous article,[6] this operation is indicated for a certain type of condition only, namely, that type which according to my classification constitutes a pathologic anatomic entity, which I have called type 1 chronic glaucoma. This is characterized by an open angle and normal depth of the anterior chamber. It includes the clinical condition commonly known as chronic simple or noncongestive glaucoma, but in addition, covers all forms in which there are a deep anterior chamber and an open angle, even though they are congested. It does not include the forms in which there are a shallow chamber and a narrow angle and the glaucoma runs a noncongestive course for many years, appearing clinically similar to and often being confused with typical chronic simple glaucoma. The procedure is especially gratifying when used as an early operation. It will be found effective also in certain cases of secondary glaucoma in which the increased intra-ocular pressure is likewise due to a block of the sclerocorneal trabeculum. It is less effective and may even be contraindicated in certain rare instances of type 1 glaucoma in which there are a high degree of vasomotor instability and a tendency toward vascular decompensation. Preliminary paracentesis may be indicated in such cases, or it may be better to employ primarily cyclodialysis or trephination.

6. Barkan, Otto: Recent Advances in the Surgery of Chronic Glaucoma, Tr. Am. Acad. Ophth. **41**:469-488, 1936; Am. J. Ophth. **20**:1237-1245, 1937.

PROVISIONAL SURVEY OF RESULTS

Results in the twenty-five eyes operated on to date will be published in detail and elaborated on later. Provisionally, it can be stated at this time that in my experience the tension in those cases in which the trabeculum has been incised over a sufficient extent of its circumference, namely one fourth, has been normalized to date, the longest period of observation being two years. In other cases in which the incision was insufficient in extent the tension has been normalized, but only with the additional use of miotics. The tension in these cases, however, was improved by the operation, since miotics had been insufficient to normalize it before operation. Reoperation in those cases in which the trabeculum was missed or the canal was not opened has not shown any effect on the intra-ocular pressure, and a further operation will be necessary. In this connection it may be noted that no damage is ever done by goniotomy and that it in no way militates against the subsequent use of other intra-ocular operations should they be desired or indicated. It seems likely that with the present improved technic a high percentage of completely successful results will be maintained and that reoperation will be required in only a few cases in which the results were incomplete.

CONCLUSION

The essence of goniotomy is its complete safety. No complications or injurious sequelae have been observed in any case in which the operation was performed to date. This makes it especially adapted to early operation, which is the greatest need in the surgical treatment of glaucoma today.

490 Post Street.

DOUBLE PERFORATIONS OF THE EYEBALL

A CLASSIFICATION

N. I. MEDVEDEF

STALINO, DONBASS, U. S. S. R.

In modern industry, in which instruments and tools of great power are in use, piercing lesions of the eyeball frequently occur. After the foreign body has passed through the wall of the eye in its anterior or anterolateral section, it still retains sufficient kinetic energy to enter the orbital cavity on its way through the vitreous and the posterior wall of the eyeball.

In rare instances such a foreign body may perforate the osseous wall of the orbit and enter the brain.

Perforating lesions of the eye or so-called double perforations of the eyeball (Hirschberg) differ considerably from the usual piercing injuries in their clinical evolution.

There is, however, practically no classification of these lesions in common use. In the articles and descriptions dealing with individual cases the authors have given arbitrary explanations of these facts. Some have accepted the indications of Hirschberg and regard as perforating lesions only those in which the foreign body is lying freely in the orbit, without being attached to the eye. Others, who form the majority, consider as cases of such lesions all those in which the foreign body has pierced the posterior, as well as the anterior, wall of the eye, whatever final localization the foreign body may have.

This divergency of opinions hinders the analysis of the material that is being accumulated and consequently detains the progress of knowledge of this question. It is a well known fact that reaction of the orbit is the first and foremost symptom of recent double perforation.

Forsmark, Rübel and Wagenmann have already noted the symptoms of recent double perforation, which have, however, not yet received sufficient consideration.

During the period between 1929 and May 1937 thirty-seven patients with double perforation of the eyeball have been treated in the Central Ukrainian Institute of Ophthalmology in Kharkov and at the ophthalmic clinic of the Donetz Mining District (Donbass). Among these patients, nineteen came for treatment within the first ten days after the accident. An analysis of the histories of disease shows that in one

case only signs of a lesion of the retrobulbar tissues were lacking. In this unique instance the injuring splinter (a fragment) was small (measuring less than 1 by 3 mm.) and was located in the orbit near the posterior wall of the eyeball. The other eighteen patients had well marked orbital symptoms.

Edema of the eyelids and chemosis of the conjunctiva of the eyeball were the symptoms which most frequently accompanied retrobulbar localization of the injuring object. Fifteen of the nineteen patients presented various degrees of reactive phenomena in the orbit. In these instances there was no infectious process in the eye itself that could have caused the reactive edema.

Exophthalmos and impairment of the movements of the eyeball were noted in ten patients.

TABLE 1.—*Distribution of Cases of Double Perforation of the Eyeball According to Localization of Foreign Body*

(Patient entered the clinic within 10 days after the accident.)

	Orbital Symptoms						
	Cases in Which Fragment Measured Over 5 Mm. in One Dimension			Cases in Which Fragment Measured Less Than 5 Mm. in Every Dimension			
Localization of Foreign Body	Considerable or Intense	Moderate or Slight	Absent	Considerable or Intense	Moderate or Slight	Absent	Total Number of Cases
1. Retrobulbar, outside eyeball...	5	1	..	3	1	..	10
2. Retrobulbar, connected with posterior portion of channel of wound.....	..	2	..	..	1	1	4
3. Fixed in wound of exit.....	2	3	..	..	..	..	5
Total.....	7	6	..	3	2	1	19

In cases of recent perforating lesion of the eyeball there often are hemorrhages underneath the skin of the eyelids and under the conjunctiva of the eyeball. Such hemorrhages, the localization of which is in no direct way connected with the anterior portion of the channel of the injuring body, were found in eight instances, i. e., in nearly half of the cases.

The present article is not intended to give a complete statement of the diagnosis, evolution and prognosis of perforating lesions of the eyeball, which I have, moreover, discussed fully in another communication.

I deem it necessary only to note the chief specific features in the semeiotics of these lesions which do not find sufficient consideration in the clinic.

I have divided all the cases of recent double perforation of the eyeball into three groups (table 1). The findings in the numerous

cases observed by my associates and me thus demonstrate that fragments which enter the orbit through the eye nearly always cause orbital symptoms.

An analysis of our material shows that orbital symptoms do not appear only in those cases of double perforation of the eyeball in which the foreign body is freely located in the orbital tissue (Hirschberg). They are likewise well marked in cases in which the foreign body is fixed in the posterior portion of the channel of the wound so that only part of it protrudes into the orbit, while the other part remains in the eye; the same is true in the case of a foreign body which has perforated the posterior wall of the eye and is localized in the orbit, where it remains in connection with the wound of exit in the sclerotic. No doubt foreign bodies in such a location (belonging to the second and third groups) have the properties of intra-ocular foreign bodies.

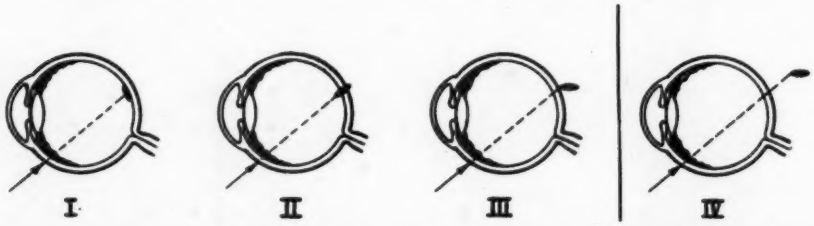

Fig. 1.—*I, II* and *III* illustrate perforating trauma of the eyeball, with lesion of the posterior wall (intra-ocular foreign body). *IV* illustrates double perforating lesion (intra-orbital foreign body).

It is also evident that when their size is sufficient they act as retrobulbar fragments would act. In view of the fact that, in consequence of the greater resistance they encounter, foreign bodies sooner loose the energy and velocity of their movement, one can easily comprehend why such large fragments are more often fixed in the posterior wall of the eyeball or remain in the neighborhood of the posterior wall, being connected with the latter. This is demonstrated in figure 1.

According to Hirschberg, one must regard severe lesions caused by a foreign body and followed by injury of the posterior wall as presented in figure 1.

Wagenmann agreed with Hirschberg in thinking that for the prognosis of further evolution and for the purpose of therapy it is most important to know whether there is complete double perforation, with the foreign body outside the eyeball, or whether the foreign body is partially fixed inside the eye.

Our material demonstrated clearly enough that fragments shown by their localization to cause lesions belonging to the second group illus-

trated in figure 1, i. e., those that are fixed in the posterior wall, and fragments that cause lesions belonging to the third group illustrated in figure 1 produced well marked orbital symptoms.

It is evident that injuries caused by foreign bodies with such a localization may not be considered as belonging to the group of those caused by the usual intra-ocular fragments.

I think it right to regard as cases of double perforation all those in which the object penetrating into the eye has caused a second wound while perforating the posterior wall of the eye.

Taking into account the ultimate evolution, depending on the position of the foreign body, I think it correct to distinguish three groups of perforating lesions of the eyeball (fig. 2).

Among cases of the first group—perforatio bulbi duplex completa—I place instances of double perforation of the eyeball in which the injuring object is found outside the eyeball, lying freely in the orbit.

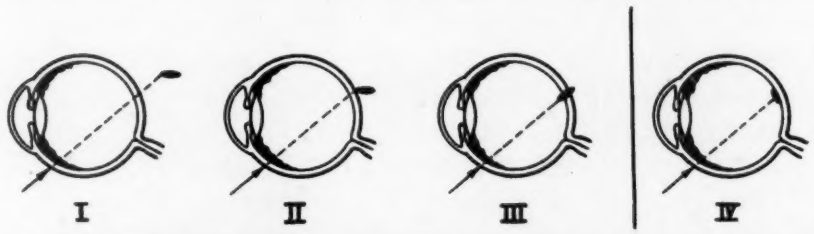

Fig. 2.—*I, II* and *III* illustrate double perforating lesion through the eyeball. In *I* the intra-orbital splinter is outside the eyeball. In *II* the splinter is outside the eyeball but connected with the posterior course of the lesion. In *III* the splinter is jammed between the borders of the posterior course of the lesion. *IV* illustrates perforation of the eyeball by an intra-ocular foreign body, with no lesion through the posterior wall.

TABLE 2.—*Distribution of Cases of Double Perforation of the Eyeball According to End-Results*

Group	Total Number of Cases	Acuity of Vision at Time of Dismissal from Clinic				
		1.0—0.5	0.5—0.1	0.1—	0	Enucleation
I	19	3	3	5	2	6
II	9	..	..	4	..	5
III	9	..	..	3	2	4
Total	37	3	3	12	4	15

Among cases of the second group—perforatio bulbi duplex fere completa— belong instances of double perforation in which the foreign body localized outside the eyeball but in connection with the wound of exit.

Among cases of the third group—perforatio bulbi duplex cum inelavatione— belong instances of lesions in which the foreign body is fixed between the edges of the wound of exit.

Table 2, which represents the end-results for the various groups of double perforation, proves that this distribution corresponds to the facts. I have chosen as the chief indicator of the end-results the acuity of vision.

CONCLUSIONS

As observations of this kind are relatively scarce, our material may be regarded as considerable. At any rate it allows one to draw some conclusions, the most important of which are these:

1. The number of cases of complete double perforation of the eyeball in which the injuring object was lying freely in the orbit amounted to only one-half the number of cases of double perforation of the eye (nineteen among thirty-seven cases).

2. The number of instances in which the foreign body had caused a perforating lesion but had stuck between the edges of the posterior portion of the channel of the wound or, having entered the orbit, was located close to the wound of exit, also amounted to about 50 per cent of all the cases.

3. The following conclusions were found to be justified, all other conditions being equal:

(*a*) In cases of perforatio bulbi duplex completa the prognosis is better than in cases of double perforation belonging to each of the other two groups. Eight of the nineteen patients have completely lost their vision, but six patients have retained good eyesight.

(b) In cases of perforatio bulbi duplex fere completa the end-results are more unfavorable than in those of the first group. Five of the nine patients became completely blind in the injured eye, while the others retained only minimal vision.

(*c*) The gravest cases are those of perforatio bulbi duplex cum inelavatione. Among nine patients with this injury there were six who lost their eyesight. The remainder retained only a minimal acuity of vision.

4. All the aforementioned kinds of trauma must be regarded as double perforation, though they ought to be differentiated according to the diagram I have just submitted (fig. 2).

5. An analysis of the clinical material according to this more precise classification will doubtlessly enrich the experience in this important problem.

EXPERIMENTAL STUDIES OF OCULAR TUBERCULOSIS

I. RELATION OF OCULAR SENSITIVITY TO CUTANEOUS SENSITIVITY IN THE SYSTEMICALLY INFECTED RABBIT

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In a previous study from the Wilmer Ophthalmological Institute [1] the factors responsible for the infection of the human eye with tubercle bacilli, for the extension and progression of such local tuberculous lesions and for their limitation and healing were discussed in the light of modern investigations. It was pointed out that ocular tuberculosis is in the main dependent on hematogenous infection arising from tuberculous lesions elsewhere in the body, usually from the hilus glands, and is only infrequently associated with active pulmonary lesions. The extension and progression of an established tuberculous lesion are due to hypersensitivity of the tissues of the eye to tuberculoprotein and to low resistance and are influenced by the number and the virulence of the invading bacilli. The limitation and healing of the tuberculous lesion are associated with low tissue sensitivity and high resistance, and are also influenced by the number and the virulence of the bacilli. In short, the inflammatory caseating and necrotizing phases of ocular tuberculosis are due to allergy, while encapsulation and healing of the lesion are due to immunity. Allergy and immunity are apparently quite unrelated, being two distinct entities. The nature of tuberculous allergy is fairly well understood, being a sensitization of the tissues by tuberculoprotein, or tuberculin, diffusing out from a tuberculous lesion. The nature of immunity is not clearly understood, but certainly there are two factors—a humoral and a cellular factor.

This work was supported by a grant from the John and Mary R. Markle Foundation.

From the Wilmer Ophthalmological Institute of the Johns Hopkins University and Hospital.

1. Woods, A. C.: The Problem of Ocular Tuberculosis, Am. J. Ophth., to be published.

In the light of these concepts, it was pointed out that the rationale of treatment of ocular tuberculosis lies in the removal of the fatal tissue hypersensitivity and the promotion of immunity. Tuberculin was formerly used for the treatment of this condition on the basis of the so-called "perifocal" concept. According to this concept, allergy and immunity are related, and immunity may be stimulated by the production of minimal perifocal allergic reactions about the focus of infection; the subsidence of the lesion indicates that immunity is established, and when the minimal lesions are produced the tuberculin is no longer needed, and its administration should therefore be discontinued. However, on the basis of the concept that allergy and immunity are unrelated, this use of tuberculin to promote perifocal minimal reactions appears to be an error. It should be used properly as a desensitizing agent, with the aim of achieving and maintaining desensitization of the tissues and of allowing the not clearly understood immunity to accomplish the encapsulation and healing of the lesion. To this end tuberculin should be used in minimal doses just beneath the patient's individual point of reactivity and should be used over long periods, irrespective of the subsidence of the lesion, to maintain any desensitization accomplished and to prevent resensitization from the quiescent local lesion. This was termed the "desensitization" concept.

In a second communication [2] the results of these two different methods of using tuberculin in the treatment of human ocular tuberculosis were reported. It was shown that distinctly better results were obtained when tuberculin was used on the basis of the desensitization concept than when it was used on the basis of the perifocal concept. These improved results were manifested both in the healing of the local lesion and in the prevention of recurrences. The influence and value of other therapeutic procedures, such as climatic treatment, drainage of the aqueous, autohemotherapy and various forms of phototherapy, were also discussed.

In relation to the fundamental tuberculin therapy, the difficulties of administering tuberculin to certain persons and of achieving and maintaining desensitization of the tissues were emphasized. It was further pointed out that there were distinct gaps in the knowledge of the relation of ocular and cutaneous sensitivity, of the influence of the local ocular lesion on ocular sensitivity and of the action of tuberculin administered subcutaneously on the remote ocular lesion. In the effort to clarify these fundamental points, the present investigations were undertaken.

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2. Woods, A. C., and Randolph, M. E.: The Treatment of Ocular Tuberculosis, Arch. Ophth. **18**:510 (Oct.) 1937.

CUTANEOUS AND OCULAR SENSITIVITY

The aim in the treatment of ocular tuberculosis with tuberculin on the basis of the desensitization concept is to abolish ocular sensitivity. There is, however, no clinical method of determining the degree of ocular sensitivity in a tuberculous eye, and the degree of cutaneous sensitivity present has been accepted as an index of the ocular sensitivity. There is abundant indirect evidence that these are not always parallel. Studies of cutaneous sensitivity to tuberculin in persons with clinically and with histologically diagnosed ocular tuberculosis [3] have shown that in 53 and 60 per cent, respectively, there was an extreme degree of cutaneous hypersensitivity, the patients reacting to an intracutaneous dose of tuberculin of 0.001 mg. or less. Forty-two per cent of those with clinically diagnosed ocular tuberculosis and 20 per cent of those with histologically proved ocular tuberculosis showed only a moderate degree of cutaneous hypersensitivity, reacting only to 0.01 or 0.1 mg.—little more hypersensitivity than is found in a normal person. The remaining patients, 5 per cent of those for whom the diagnosis was proved clinically and 20 per cent of those for whom it was proved histologically, were nearly or totally insensitive cutaneously, reacting only to 1 mg. or not at all. With the first group of patients, those with high cutaneous sensitivity, there is probably justification for assuming that there is also a high degree of ocular sensitivity, and the therapeutic use of tuberculin may be undertaken with reasonable confidence. With the other two groups of patients, those with moderate or low cutaneous sensitivity, the use of tuberculin can be justified only on the assumption that cutaneous and ocular sensitivity in these persons are not parallel and that there exsits a definite degree of ocular sensitivity to be attacked by the subcutaneous injection of tuberculin, either through its general effect or through a local effect by the mobilization and concentration of the injected tuberculin about the inflamed and hypersensitive focus.

One of the primary aims of these studies was to determine what relation, if any, exists between cutaneous and ocular sensitivity. In order to simulate the condition under which ocular tuberculosis occurs in human beings, this must finally be determined in animals previously inoculated systemically with tubercle bacilli and later inoculated intraocularly. However, before this can be studied and the results properly evaluated, the relation of ocular and cutaneous sensitivity in the animal with systemic tuberculosis only must be determined. The first problem, therefore, is to determine to what extent the eye participates in the hypersensitivity to tuberculin in the animal with systemic tuberculosis. The purpose of this paper is to report investigations on this question.

3. Friedenwald, J. S., and Dessoff, J.: Value of Intracutaneous Tuberculin Test in Diagnosis of Ocular Tuberculosis, Bull. Johns Hopkins Hosp. **57**:148, 1935.

TECHNIC

Preparation of Cultures.—In preliminary experiments considerable difficulty was experienced with the stock strains of tubercle bacilli. In rabbits infected with the avirulent R1 bacillus, neither cutaneous sensitivity nor tuberculous lesions developed. On rabbits infected with the virulent H37 strain, sensitivity or local lesions developed only irregularly. In May 1935 a strain of tubercle bacilli which was highly virulent for guinea pigs was isolated from human sputum. This organism was used throughout this experiment. It was cultured either in the synthetic medium of Proskauer and Beck [4] or on hormone bouillon containing 5 per cent glycerine, adjusted to a p_H of 7. The age of the cultures used varied from four to eight weeks.

Choice of Animals.—With the idea of avoiding any possible strain or age tendency toward sensitization or immunity, mongrel rabbits of various ages and breeds were used throughout this experiment.

Inoculation.—Systemic infection was obtained by subcutaneous injection in the groin of 0.25 cc. of a thick salt solution emulsion of living tubercle bacilli.

Sensitization Tests.—All tests for both cutaneous and ocular sensitivity were done with the purified protein derivative of the tubercle bacillus, isolated first by Seibert.[5] The commercial preparation was used. This preparation is entirely nonantigenic, and any confusion of results incident to possible sensitization of the rabbits through repeated doses was therefore avoided. A stock solution containing 0.5 mg. per cubic centimeter in physiologic solution of sodium chloride with 0.5 per cent cresol U. S. P. was prepared. On the day the tests were done, dilutions of this stock solution of 1 : 10, 1 : 100 and 1 : 1,000 were made. The cutaneous sensitivity was determined by injecting 0.1 cc. of these dilutions intracutaneously into the clipped backs of the rabbits, the test doses therefore being 0.005, 0.0005 and 0.00005 mg. At the end of forty-eight hours these tests were read for erythema, elevation, induration and necrosis on a scale of from 0 to 4. The final result, indicating the degree of cutaneous sensitivity present, was estimated from these readings, again on a scale of from 0 to 4. The ocular sensitivity was determined by the injection of the purified protein derivative into the anterior chamber of both eyes, 0.01 mg. being injected into the right eye and 0.001 mg. into the left eye. Local anesthesia was used for the injections into the anterior chamber. The needle of the syringe, containing 0.2 cc. of the solution to be injected, was introduced into the anterior chamber, the aqueous was withdrawn and the mixture was pushed back and forth several times. It had been ascertained by previous experiments that ten times this dose of purified protein derivative, 0.1 mg., gave no reaction when similarly injected into the anterior chamber of the eye of a normal rabbit.

The eyes were examined clinically forty-eight hours after the injection. The degree of ciliary injection, steaminess of the cornea, turbidity of the aqueous, inflammatory change in the iris and any ophthalmoscopic change were noted individually in each eye and evaluated on a numerical scale of from 0 to 4. An

4. Proskauer, B., and Beck, M., cited by Baldwin, E. R.; Petroff, S. A., and Gardner, L. S.: Tuberculosis: Bacteriology, Pathology and Laboratory Diagnosis with Sections on Immunology, Epidemiology, Prophylaxis and Experimental Therapy, Philadelphia, Lea & Febiger, 1927.

5. Seibert, F. B.: Isolation and Properties of Purified Protein Derivative of Tuberculin, Am. Rev. Tuberc. **30**:713, 1934.

average of these readings gave a numerical index of the degree of reaction in each eye, and the degree of ocular sensitivity was finally expressed as an average of the reaction in the two eyes.

The animals were then killed and the eyes were enucleated, sectioned and studied histologically by one of us, without knowledge of the clinical reading. On the same scale, from 0 to 4, numerical values were assigned to the degree of pericorneal infiltration present, to cellular deposits on the cornea, to serum in the anterior chamber and to the cellular reaction on the iris and the ciliary body. An average of these readings from the two eyes gave a final numerical value to the degree of the histologic reaction.

Controls.—To control any traumatic reaction, and as a control for the solution of purified protein derivative used, a normal rabbit was given intracutaneous and intra-ocular injections at the same time as each pair of test animals and was similarly killed and studied.

Outline of Experiment.—Forty-eight normal rabbits were first given an intracutaneous test injection of purified protein derivative and were found to be insensitive. They were then infected systematically by an injection of living human tubercle bacilli into the groin. At intervals of one week two of these animals were tested both for cutaneous and for ocular sensitivity and were then killed so that the tested eyes could be examined histologically. A normal rabbit was similarly tested and killed each week to serve as a control on the two test animals. There were available, therefore, two observations on both the cutaneous and the ocular sensitivity of systemically infected animals at weekly intervals over a period of sixteen weeks during the progressive stages of the tuberculous infection. The observations were necessarily made on different animals, but all were infected at the same time with the same inoculism. To determine the late outcome of the infection and the duration of the cutaneous and the ocular sensitivity, seven additional animals were systemically infected, and the sensitivity was determined eight months after inoculation.

RESULTS

Course of Systemic Infection.—Human tuberculosis in rabbits is a self-limited disease which does not kill the rabbit, the infection usually being overcome within four months. The rabbits in this experiment throve and gained weight after the systemic inoculation. About two weeks after the injection into the groin, a nodule varying in size from 1 to 3 cm. in diameter appeared at the site of inoculation. Rarely did a rabbit show general lesions of disseminated tuberculosis. The animals on which autopsy was performed up to eight months after infection, with one exception, did not show gross or histologic evidence of generalized tuberculosis. The tuberculous process was limited, as a rule, to the local lesion at the site of inoculation.

Relation of Ocular and Cutaneous Sensitivity.—Graphs can best demonstrate the relation of the cutaneous and the ocular sensitivity. Since two animals were killed each time observations were made, three graphs were obtained illustrating, respectively, the cutaneous sensitivity and the clinical and the histologic sensitivity of the eye. These are

shown in charts 1 and 2. Chart 1 shows the ocular and the cutaneous sensitivity of the rabbits which each week showed the highest degree of cutaneous sensitivity, and chart 2 shows the same data for the rabbits which manifested the lowest degree of cutaneous sensitivity.

With minor variations, the curves are in the main similar, varying chiefly in the degree of reaction. Both cutaneous and ocular sensitivity first appeared synchronously at the end of the third week after inocu-

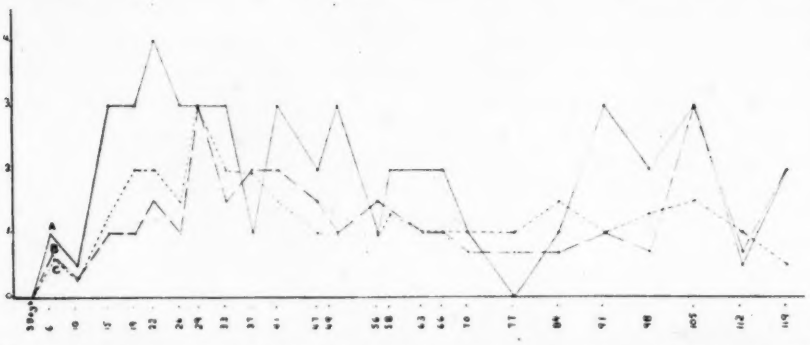

Chart 1.—Curves showing the degree of ocular and cutaneous sensitivity in the systemically infected rabbits that showed the highest degree of cutaneous reactivity. In this chart and in chart 2 curve *A* represents the cutaneous sensitivity; curve *B*, the clinical ocular sensitivity, and curve *C*, the histologic ocular sensitivity.

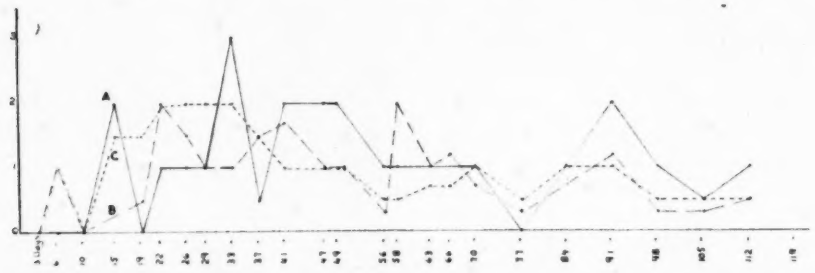

Chart 2.—Curves showing the degree of ocular and cutaneous sensitivity in the systemically infected rabbits that showed the lowest degree of cutaneous reactivity.

lation and reached their peak from six to eight weeks after systemic inoculation. Thereafter they fluctuated within minor limits for a further period of from six to eight weeks, when a fairly constant equilibrium was reached. At the end of four months both cutaneous and ocular sensitivity were present to a moderate and approximately equal degree. At the end of eight months, when the last rabbits were killed, the degree of both cutaneous and ocular sensitivity was only slightly less than that at the end of four months, the cutaneous and the ocular sensitivity measuring 1+ on the scale of from 0 to 4 (charts 1 and 2).

COMMENT

As the test animals were killed each week to permit histologic examination of the tested eyes, the weekly estimations of the degree of sensitivity are for different animals. Although the animals were all similarly infected at the same time, the results are nevertheless subject to individual variation in susceptibility to sensitization. Despite this possible source of confusion, the curves of both ocular and cutaneous sensitivity are remarkably parallel and show clearly that the normal eye apparently participates equally in the general sensitivity to tuberculoprotein shown by other body tissues. This is emphasized by the fact that the animals chosen for the lower degree of cutaneous sensitivity likewise showed a lower degree of ocular sensitivity.

Two sharp breaks occur in the curves of cutaneous sensitivity, the estimation on the thirty-seventh and the seventy-seventh day being markedly lower than on either the preceding or the following weeks. The cause of this sharp decrease in cutaneous sensitivity, without noticeable change in either the clinical or the histologic ocular sensitivity, is not clear. It seems more probable it is due to some technical error on our part than to individual variation in the susceptibility of the test animals. The other minor fluctuations in cutaneous sensitivity shown throughout may be due to a variety of causes, such as individual variations in the rabbits or possibly the result of environment or weather on the reactivity of the skin.

The close parallelism of the curves illustrating the clinical and the histologic degree of ocular sensitivity are rather remarkable, especially since these estimations were made independently by different investigators, the histologist having no knowledge of the value assigned the clinical reactions.

CONCLUSIONS

Under the conditions of this experiment, the undiseased eyes of rabbits infected systemically with human tubercle bacilli participate in the general sensitivity to tuberculoprotein developed by the skin. Both ocular and cutaneous sensitivity develop synchronously about the third week and reach their peak about the sixth to the eighth week. Thereafter they fall slightly and reach an equilibrium but are still present eight months after the original inoculation.

The cutaneous sensitivity gives a fairly reliable index of the degree of ocular sensitivity in the systemically infected rabbit with undiseased eyes.

The Mulford Biological Laboratories, Sharp & Dohme, supplied the purified protein derivative used in these tests, and Miss Rosa Himelfarb gave technical assistance.

EXPERIMENTAL STUDIES OF OCULAR TUBERCULOSIS

II. RELATION OF OCULAR ACTIVITY TO OCULAR SENSITIVITY IN THE NORMAL RABBIT INFECTED BY INJECTION OF TUBERCLE BACILLI INTO THE ANTERIOR CHAMBER

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In the first paper of this series,[1] attention was directed to certain phases of the general problem of ocular tuberculosis and especially to the rudimentary state of knowledge concerning the relation of cutaneous sensitivity, ocular sensitivity and ocular activity. The results of an investigation on the relation of cutaneous and ocular sensitivity in the normal rabbit infected by systemic injection of human tubercle bacilli were reported. Ocular sensitivity was found to develop synchronously with cutaneous sensitivity, the nondiseased eyes participating in the general development of tissue sensitivity. With minor variations, during the course of this self-limited disease in the rabbit cutaneous and ocular sensitivity ran fairly parallel, reaching their peak from six to eight weeks after systemic inoculation, declining slightly as the animal overcame the infection, but being definitely present for at least nine months after infection, when the last rabbits were tested.

The next step in this study is the determination of the mutual influence and relation of local tuberculous inflammation and ocular sensitivity. That some change in ocular sensitivity may follow an attack of tuberculous inflammation was indicated by an inconclusive experiment on human eyes.[2] In this experiment, performed on eyes already

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This work was supported by a grant from the John and Mary R. Markle Foundation.

From the Wilmer Ophthalmological Institute of the Johns Hopkins University and Hospital.

1. Woods, A. C.; Burky, E. L., and Friedenwald, J. S.: Experimental Studies of Ocular Tuberculosis: I. Relation of Ocular and Cutaneous Sensitivity in the Systemically Infected Rabbit, Arch. Ophth., this issue, p. 229.

2. Woods, A. C.: The Problem of Ocular Tuberculosis, Am. J. Ophth., to be published.

lost because of repeated former attacks of tuberculous uveitis, it was found that the vascular reactivity of these eyes to tuberculin, as determined by a graduated Calmette reaction, was lessened or exhausted with the subsidence of an exacerbation of the local inflammation.

The purpose of this paper is to report the results of experiments on the relation between tuberculous inflammation and ocular sensitivity in normal animals infected ocularly by injections of tubercle bacilli into the anterior chamber. It is apparent that this picture of ocular tuberculosis in an otherwise normal animal is an artificial experimental condition, in no way comparable to the picture of ocular tuberculosis in man, in whom the ocular disease is secondary to some systemic focus. Nevertheless, the relation between ocular activity and ocular sensitivity must be determined first in the normal animal in order that it may later be properly studied and interpreted in the animal with a previous systemic infection and a secondary ocular infection.

PLAN OF EXPERIMENT

Forty-eight normal rabbits were first tested intracutaneously with 0.05 mg. of purified protein derivative of the tubercle bacilli and were found to be insensitive. They were then inoculated by means of a suspension of living tubercle bacilli injected into the anterior chamber. The entire group was tested intracutaneously at weekly intervals with graduated doses of purified protein derivative to determine the development of cutaneous sensitivity. The eyes were examined clinically each week, and the amount of tuberculous activity present was estimated. Again, at weekly intervals, simultaneous with the determination of cutaneous sensitivity, the degree of ocular sensitivity of each eye was determined in two of the rabbits by clinical examination of the eyes after the intra-ocular injection of purified protein derivative. The two animals were then killed, and the eyes were sectioned and examined histologically to determine the histologic evidence of allergy, the reaction produced by the injection of purified protein derivative and the course of the tuberculous infection. For each pair of experimental animals, a normal control animal was given a similar injection, and the eyes were sectioned and studied.

Six eyes perforated spontaneously as a result of tuberculous uveitis and became secondarily infected. These animals were discarded, leaving forty-two rabbits, which formed the material for this experiment.

TECHNIC

Preparation of Cultures.—A salt solution emulsion of the same human bacillus used in the first experiment was prepared as already described. For intra-ocular injection, this emulsion was filtered through filter paper, an opalescent suspension resulting. A smear was made, which was stained and examined under oil immersion, and the number of bacilli present were counted. Usually from 50 to 500 organisms were present to each oil immersion field. This paper filtrate of the original emulsion was then diluted from 1:10 to 1:100, according to the number of bacilli present, the aim being to have a final suspension containing approximately 5 organisms to each oil immersion field.

Animals and Inoculation.—Mongrel rabbits of varying age and breed were used, as in the first experiment. The right eye of each rabbit was inoculated by means of an injection into the anterior chamber of 0.2 cc. of the final suspension, the mixture of aqueous and bacilli being withdrawn and reinjected several times to insure a uniform suspension of the bacilli in the anterior chamber. Local anesthesia was used. This dosage and method of inoculation had been shown by previous experiment to produce in the rabbit a fairly uniformly progressive ocular tuberculosis with subsequent scarring.

Determination of Cutaneous and Ocular Sensitivity.—Cutaneous sensitivity was determined in the manner described before. The rabbits were all tested weekly by the intracutaneous injection in the clipped back of 0.005, 0.0005 and 0.00005 mg. of purified protein derivative. The results were read at the end of forty-eight hours for erythema, elevation, induration and necrosis on a scale of from 0 to 4, the final average being the numerical value assigned to the cutaneous reaction.

The ocular sensitivity was determined synchronously on two animals by the intra-ocular injection of 0.01 mg. of purified protein derivative into the anterior chambers of both the inoculated right eye and the normal left eye, it having been previously determined that ten times this dose produced no reaction when injected in the anterior chamber of a normal rabbit's eye. Immediately before the injection of purified protein derivative, the degree of ocular activity in the diseased eye was carefully noted. At the end of forty-eight hours the eyes were again examined, and the degree of activity then present was noted. The amount of heightened inflammation or the difference in inflammation before and after the injection represents the vascular reaction of these eyes to the purified protein derivative.

The animals were killed, and the eyes were enucleated, sectioned and studied histologically. Throughout the progressive stages of the disease, the normal left eye showed a definite cellular reaction to the injection of purified protein derivative, and by estimation of the pericorneal infiltration, the cellular deposits in the cornea, the amount of serum in the anterior chamber and the cellular reaction of the iris and ciliary body, a numerical value could readily be assigned, indicating the degree of histologic sensitivity. Caseation and necrosis were never observed in these eyes.

In the inoculated right eye, the situation was quite different. During the first four weeks of the disease it was impossible by histologic examination to differentiate the reaction caused by the injection of purified protein derivative from the diffuse tuberculous infiltration caused by the bacilli themselves. In the fifth week typical allergic caseation and necrosis became evident and persisted to a high degree up to the sixteenth week, with little variation. From the sixteenth to the twenty-first week caseation and necrosis rapidly subsided, and the eyes showed scarring and evidence of repair.

The histologic evidence, therefore, indicates that allergy, or hypersensitivity of the ocular tissues, was present from the fifth to the sixteenth week after inoculation. Some caseation was seen clinically in these eyes before the injection of purified protein derivative. The caseation and necrosis observed histologically may therefore have been due to two factors, a reaction secondary to the tuberculous inflammation and a reaction to the purified protein derivative. The relatively mild scarring present in the eyes enucleated in the last five weeks of the experiment, when caseation due to the tuberculous inflammation was in process of repair, would indicate that the greater portion of the caseation and necrosis was due to the injection of purified protein derivative. This is, however, an academic point. Suffice it to say, histologic examination revealed evidence of a high degree of hypersensitivity from the fifth to the sixteenth week after inoculation, and thereafter allergy faded rapidly.

The correlation of the clinical and histologic estimations of ocular sensitivity is complicated by the fact that from the eighth to the sixteenth week the injection of purified protein derivative into the anterior chamber produced little accentuation of the inflammatory reaction in the diseased eyes. During this period the tuberculous eyes showed opaque and vascularized corneas, clinical evidence of caseation and a rapidly subsiding vascular reaction. It was at first not clear whether this absence of accentuation of the vascular reaction after the injection of purified protein derivative was due to subsidence of the ocular sensitivity or to a blocking off of the blood vessels by the caseation and cellular infiltration and a consequent loss of vascular response to any stimulus. The diseased eyes of control animals in this stage of tuberculosis were therefore inoculated by injection of living virulent staphylococci into the anterior chamber. In normal eyes this injection produced a marked vascular and pyogenic reaction. In the caseating tuberculous eyes, apparently nonreactive to the purified protein derivative, the injection of staphylococci produced no vascular reaction and almost no pyogenic reaction. It is therefore evident that the apparent lack of reaction to purified protein derivative should not be attributed to a lack of ocular sensitivity but was probably due to vascular nonreactivity secondary to the blocking off of the blood vessels by caseation. Only after the sixteenth week, when the caseation subsided, was a moderate return of the vascular reaction to the injection of purified protein derivative noted.

Plotting of the Graph of Ocular Sensitivity.—A graph plotted to demonstrate ocular sensitivity must therefore be a composite one. In the first four weeks, before caseation was apparent, the heightened inflammation observed clinically after the injection of purified protein derivative gave the most reliable index of the ocular sensitivity, for the reaction produced could not be differentiated histologically from the tuberculous infiltration caused by the bacilli. After the appearance of caseation and necrosis, when the vascular reactivity of the eye to purified protein derivative began to fade, histologic evidence indicated a maximal ocular sensitivity up to the sixteenth week. Thereafter there was histologic evidence of rapidly subsiding ocular sensitivity associated with a mild degree of clinical vascular reaction. On the basis of this information, the graph of ocular sensitivity was plotted. The graph for the first four weeks was plotted on the clinical estimations of allergy; that for the next twelve weeks, on the histologic evidence of allergy, and that for the last five weeks, on the mean of the clinical and histologic estimations.

Course of Ocular Tuberculosis (Ocular Activity).—The clinical picture of ocular tuberculosis developed by all these rabbits was limited to the anterior ocular segment. As long as the cornea and aqueous remained sufficiently clear to permit ophthalmoscopic examination of the fundus, no lesions were observed in the retina or choroid or about the optic nerve. Histologic examination of the enucleated eyes, however, showed in addition to the tuberculous inflammation of the anterior ocular segment an occasional spread of the reaction to the posterior segment.

The two rabbits killed in the first two weeks did not yet show any clinical signs of ocular tuberculosis. One other rabbit was apparently highly immune and showed little inflammatory reaction. The pericorneal congestion in this rabbit was only moderate, the cornea remained clear and the vascularization present was limited to a small zone at the periphery. The iris uniformly showed chronic thickening and loss of normal luster and markings, with numerous hard tubercles studded over the anterior surface. The course of the ocular tuberculosis in the remaining thirty-nine rabbits was more or less constant, with minor individual variations.

The greater number of the rabbits, thirty-five, or 80 per cent of the entire number, showed, first, a slowly progressive inflammation, beginning about two weeks after inoculation and characterized by pericorneal congestion and steaminess and later by vascularization of the cornea, an increase in the aqueous ray and chronic inflammatory changes in the iris, often with tubercule formation. This indolent reaction gradually became aggravated about the fourth week, and the eyes entered the second stage, with aggravated inflammation and obvious caseation and necrosis. Four of these thirty-five eyes finally perforated. In four rabbits the inflammation and caseation were more acute, the eyes perforating within six weeks. The acute inflammation, as manifested by the vascular reaction, began to subside about the eighth week, and by the tenth week there was only low grade ciliary inflammation. For the next six weeks the eyes showed a caseating

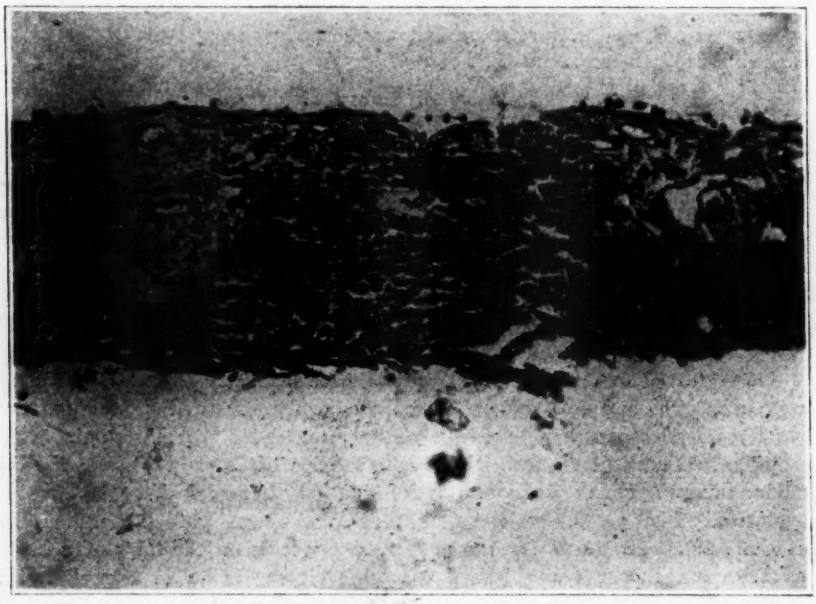

Fig. 1.—Section of the eye four weeks after inoculation of the anterior chamber, showing a hard tubercle of the iris.

inflammation and little vascular reaction. Thereafter they entered the third stage, of scarring and repair. The eyes that were enucleated in the last five weeks of the experiment showed, with one exception, scarred and vascularized corneas, often buphthalmos or corneal ectasia, but no active congestion or necrosis.

The histologic reaction of the enucleated eyes showed that the entire reaction during the twenty-one weeks fell roughly into three general stages. During the first four weeks there was diffuse tuberculous infiltration with hard tubercles, masked somewhat by the reaction incident to the injection of purified protein derivative (fig. 1). From the fifth to the sixteenth week the eyes showed extension of the inflammation, caseation and necrosis with masses of dead epithelioid cells (fig. 2). From the sixteenth to the twenty-first week, when the experiment was terminated, with only one exception, the eyes were free from caseation and showing evidence of healing and repair (fig. 3).

Fig. 2.—Section of the eye eight weeks after inoculation of the anterior chamber, showing caseation and necrosis of the iris.

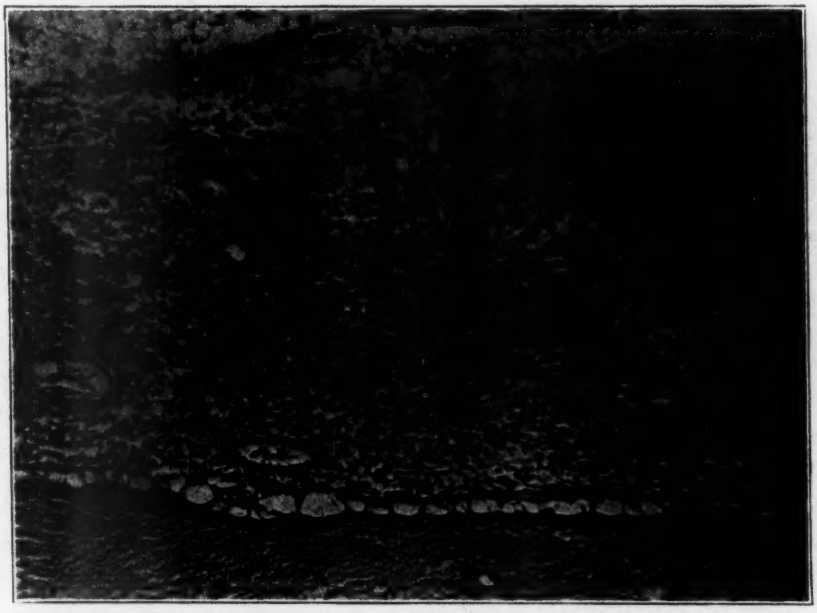

Fig. 3.—Section of the eye twenty weeks after inoculation of the anterior chamber, showing connective tissue infiltration and repair.

The first clinical stage, of infiltration, and the final stage, of inactivity and repair, agree well with the histologic picture. The second clinical stage of acute vascular inflammation, from the fourth to the tenth week, was much shorter than the histologic stage of acute inflammation, which persisted up to the sixteenth week. This discrepancy was due to the loss of vascular reactivity from the caseation. As already pointed out, the vascular reactivity of these eyes to purified protein derivative as well as to such a nonspecific irritant as living staphylococci was greatly reduced after the eighth week.

Plotting of the Graph of Ocular Activity.—The final graph of ocular activity was plotted as the mean of the clinical and histologic readings. The gradual drop of the curve after the eighth week reflects the loss of vascular reactivity. A graph plotted on the estimations of clinical activity only, as in figure 4, shows a much more striking apparent decrease in clinical inflammation occasioned by the loss of vascular reactivity. The curve slopes sharply downward after the eighth week.

The comparison of ocular activity and ocular sensitivity in this experiment is based on observations made on the two animals killed weekly. This introduces an element of individual variation. That this element is negligible is shown by

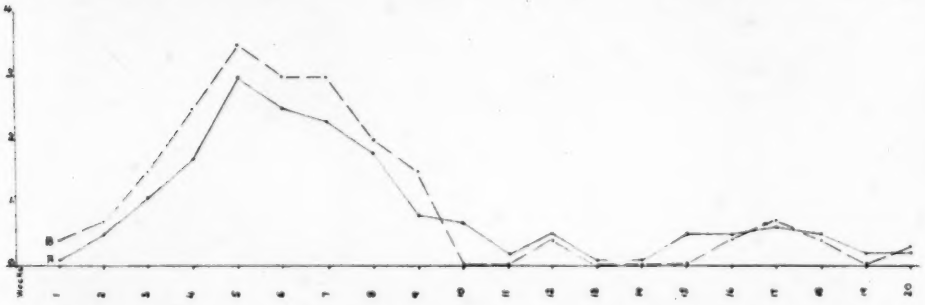

Fig. 4.—Average clinical ocular activity for the entire group of rabbits (curve *A*) and for the pairs of rabbits tested at weekly intervals (curve *B*).

figure 4. In this figure curve *A* shows the average clinical ocular inflammation shown by all the surviving rabbits of the group. Curve *B* shows the average clinical inflammation shown by the pairs of rabbits killed weekly. Since these curves are almost identical, it appears that the pairs of rabbits killed weekly are a fair sample of the entire group.

RESULTS

Relation of Clinical Ocular Activity and Ocular Sensitivity.—Figure 5 shows the graphs of clinical ocular activity and ocular sensitivity in the pairs of rabbits killed over the twenty-one weeks of the experiment. During the first five weeks after inoculation, while the tubercle bacilli propagated and the infection spread throughout the eye, inflammation and ocular sensitivity increased together to the maximum. After caseation and necrosis appeared in the fifth week, there was an apparent decrease in inflammation. There was still, however, a high degree of allergy present until the sixteenth week. At this point the allergic response of the tissues appeared exhausted, and both ocular sensitivity and inflammation rapidly faded. As already pointed out, the apparent

decrease in ocular activity from the fifth to the sixteenth week represents the loss of vascular reaction of the diseased eyes and is not an index of a fading ocular tuberculosis but only a reflection of the blocking off of the vascular network by the existing inflammation and caseation. Histologic evidence clearly shows that the spread of the tuberculous lesion and the sensitivity of the ocular tissues go hand in hand, and healing occurs only when the ocular sensitivity is diminished and abolished.

Relation of Recurrences to Resensitization.—In the latter weeks of this experiment three individual rabbits, which had apparently reached a stage of complete clinical inactivity, showed definite recurrences of inflammation, with a lighting up of the pericorneal inflammation and evidences of renewed activity. They were killed at this stage. The eyes showed a clinical reaction to the injection of purified protein derivative into the anterior chamber two days before the animals were killed. It is possible that the apparent exacerbation of the tuberculosis and syn-

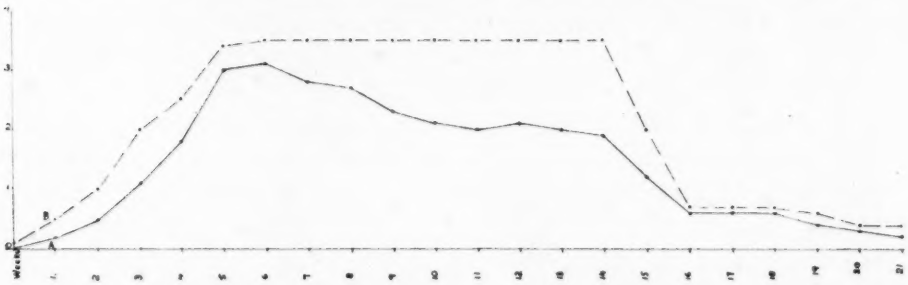

Fig. 5.—Curves showing the relation of ocular inflammation to ocular sensitivity. Curve *A* represents the ocular inflammation and curve *B*, the ocular sensitivity.

chronous return of reactivity of the eye to the purified protein derivative may be only an evidence of recurring vascular reactivity in the eye. On the other hand, it may indicate a resensitization of the tissues after a period of rest, with a resultant exacerbation of tuberculous infiltration. In either event, it is notable that the three rabbits which showed recurrences of inflammation also showed a return of clinical ocular reaction to the purified protein derivative.

COMMENT

The findings here reported give an experimental explanation for the already reported inconclusive experiment on human beings. The acute inflammatory stages of tuberculous ocular lesions appear only in the presence of sensitivity of the ocular tissues. Until demonstrable sensitivity is present in the eye, the tuberculous lesion runs a low grade,

smoldering course. The progression of the acute inflammatory stage is accompanied by a gradual diminution or exhaustion of the vascular reactivity of the eye. After the ocular sensitivity is exhausted, the eyes become quiescent, and healing and scarring occur. There is suggestive evidence in three rabbits that vascular reactivity to purified protein derivative and clinical exacerbations of the tuberculous activity occur synchronously.

The process might theoretically be visualized as follows: After infection of the normal eye with tubercle bacilli there is a steady propagation of the bacilli, invasion of tissues and tubercle formation. The diffusion of tuberculoprotein in the hitherto normal tissue produces first a tissue sensitization. After this is established, the further diffusion of tuberculoprotein from the lesion produces an allergic inflammatory reaction characterized by caseation and necrosis. With the neutralization of the tissue reagin, the allergic reaction subsides, and the eye becomes quiescent. Clinical inflammation may recur when the ocular tissues either recover their vascular reactivity or become resensitized.

How might this resensitization of the eye occur? In such animals as these, with the only tuberculous focus in the eye, it must be supposed that resensitization is the result of the continued diffusion of tuberculoprotein from the local lesion, resensitization occurring after the tissues have passed from a negative phase after neutralization of the available reagin into a positive susceptible phase. In the systemically infected animal, resensitization of the eye might readily take place from a remote lesion, it already having been shown that in the systemically infected animal the eye participates in the general tissue sensitivity.

CONCLUSIONS

After infection of the eyes of a normal rabbit with tubercle bacilli, the initial tuberculous process is a low grade tuberculous infiltration with formation of hard tubercles.

Ocular sensitivity to tuberculoprotein becomes apparent at the end of the second week and maximal by the fifth week.

With the establishment of ocular sensitivity, the eyes show an acute inflammatory phase. This acute inflammation is accompanied by caseation and necrosis and produces first an exhaustion of the vascular reactivity of the eye. This in turn is followed by an exhaustion of the ocular sensitivity, and synchronous with the fading of ocular sensitivity, healing and scarring are observed.

Recurrences of ocular activity occurred synchronously with the return of vascular reactivity to purified protein derivative.

The Mulford Biological Laboratories, Sharp & Dohme, supplied the purified protein derivative used in these tests, and Miss Rosa Himelfarb gave technical assistance.

EXPERIMENTAL STUDIES OF OCULAR TUBERCULOSIS

III. RELATION OF CUTANEOUS SENSITIVITY TO OCULAR SENSITIVITY IN THE NORMAL RABBIT INFECTED BY INJECTION OF TUBERCLE BACILLI INTO THE ANTERIOR CHAMBER

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AND

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BALTIMORE

In the first study of this series [1] it was found that in rabbits systemically inoculated with human tubercle bacilli the eye participated in the general body sensitivity developing after inoculation. Ocular sensitivity developed synchronously with cutaneous sensitivity, and, with minor variations, ran a fairly parallel course, the cutaneous sensitivity affording a reasonably accurate index of the sensitivity of the undiseased eyes. In the second study it was pointed out that when the normal rabbit was inoculated with tubercle bacilli in the anterior chamber and the primary tuberculous focus lay in the eye, ocular sensitivity began to develop about the second week after inoculation and reached its height in about four weeks. The eyes showed a slowly progressive tuberculous inflammation during the first few weeks, which became acute, with caseation and necrosis, as the ocular sensitivity developed to maximum. Active tuberculous inflammation and ocular sensitivity persisted steadily up to the sixteenth week, although about the eighth week there was some loss of vascular reactivity, apparently due to the blocking of the vascular bed by necrosis. From the sixteenth to the twenty-first week, when the experiment was terminated, the ocular sensitivity faded and the active inflammation subsided synchronously, the eyes thereafter showing evidence of scarring and repair. In the final stage of compara-

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This work was supported by a grant from the John and Mary R. Markle Foundation.

From the Wilmer Ophthalmological Institute of the Johns Hopkins University and Hospital.

1. Woods, A. C.; Burky, E. L., and Friedenwald, J. S.: Experimental Studies of Ocular Tuberculosis: I. Relation of Ocular and Cutaneous Sensitivity in the Systemically Infected Rabbit, Arch. Ophth., this issue, p. 229.

tive inactivity there were occasional minor exacerbations of inflammation. There was suggestive evidence that these exacerbations of activity were related to the presence or return of the ocular sensitivity.

The next step in these studies was an analysis of the relation of ocular sensitivity to cutaneous sensitivity in the normal rabbit inoculated intra-ocularly by means of an injection of tubercle bacilli into the anterior chamber.

OUTLINE OF EXPERIMENT

The rabbits on which this study was based are the same rabbits used in the second study on the relation of ocular sensitivity to ocular activity. Forty-eight normal rabbits were first proved insensitive to an intracutaneous injection of 0.005 mg. of purified protein derivative of tubercle bacilli. Then 0.2 cc. of a suspension of living human tubercle bacilli was injected into the anterior chamber of the right eye of each rabbit. During the course of the experiment six animals were discarded on account of perforation of the eyes, with secondary infection. At weekly intervals the eyes of all surviving rabbits were examined clinically, and a numerical value was assigned to the degree of tuberculous activity and inflammation present. The rabbits were likewise tested intracutaneously at the same time for cutaneous hypersensitivity to the purified protein derivative, to which a numerical value was assigned. Each week the ocular sensitivity of both the inoculated and the normal eye was determined by the injection of purified protein derivative into the anterior chamber of two rabbits, which were then killed for histologic examination of the tested eyes. There were therefore available for analysis weekly estimations of the cutaneous sensitivity and ocular activity of all the surviving rabbits, the number steadily diminishing as the experiment progressed, and estimations of the ocular sensitivity in both the inoculated and the normal eye of the separate pairs of rabbits killed in progressive stages of the ocular tuberculosis.

TECHNIC

The technic employed in inoculation and the determination of both cutaneous and ocular sensitivity has already been reported in the second paper of this series.[2]

The graph representing cutaneous sensitivity was based on the clinical reading of the intracutaneous tests with purified protein derivative. The graph representing ocular activity was based on the mean of the clinical and histologic estimations. As already pointed out, the subsidence of activity from the eighth to the sixteenth week is a reflection of the loss of vascular reactivity incident to the development of caseation and necrosis. The plotting of the graph of ocular sensitivity was explained in the second paper of this series. The graph for the first four weeks was based on the clinical examination; that for the ensuing twelve weeks, on the histologic examination of the eyes, and that for the final five weeks, on the mean of the histologic and clinical estimations.

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2. Woods, A. C.; Burky, E. L., and Friedenwald, J. S.: Experimental Studies of Ocular Tuberculosis: II. Relation of Ocular Activity to Ocular Sensitivity in the Normal Rabbit Infected by Injection of Tubercle Bacilli into the Anterior Chamber, Arch. Ophth., this issue, p. 236.

RESULTS

It was shown in the second study that the average clinical ocular activity of the group as a whole was practically identical with the average activity shown by the pairs of rabbits killed at weekly intervals, and therefore the individual pairs of rabbits appear to offer a reliable index of the reactions of the whole group.

Sensitivity in the Normal Uninoculated Eye.—As in the experiment with the systemically infected rabbits, sensitivity to purified protein derivative began to develop in the normal uninoculated eye at the second week; it reached a peak about the end of the third week, and thereafter continued, with minor fluctuations, during the twenty-one weeks of the experiment. The sensitivity in the normal eye declined only slightly during this period. Again, as in the systemically infected animal, the clinical and histologic estimations ran closely parallel. The graphs of these estimations are shown in chart 1. The ocular sensitivity shown by the normal uninoculated left eye of these rabbits was essentially

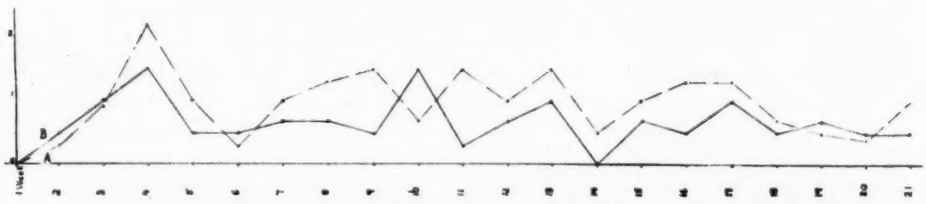


Chart 1.—Curves showing the histologic and the clinical sensitivity of the left eye after inoculation of the anterior chamber of the right eye with tubercle bacilli. Curve *A* represents the histologic sensitivity, and curve *B*, the clinical sensitivity.

of the same degree as that in the normal eyes of rabbits infected by systemic injection.

Development of Cutaneous Sensitivity.—Cutaneous reactions to purified protein derivative became evident at the end of the second week after inoculation of the anterior chamber, reached their peak about the fifth or the sixth week, then declined and, with minor fluctuations in intensity, continued at a low level during the twenty-one weeks of observation.

It is notable that the cutaneous reactions in these animals with the primary tuberculous focus in the eye were distinctly less than those in the systemically infected rabbits. In chart 2 the cutaneous reactions in the systemically infected rabbits, reported in the first study, may be compared with the cutaneous sensitivity of the rabbits in this experiment. In both instances the reactions represent the average of the pairs of rabbits killed weekly, and they were read and checked on the same scale. The cutaneous sensitivity which develops secondary to a local

tuberculous process in the eye appears to be decidedly less than that which develops after systemic infection.

Relation of Sensitivity in the Uninoculated Eye to Cutaneous Sensitivity.—The graphs illustrating the relation of sensitivity in the uninoculated eye to cutaneous sensitivity are shown in chart 3. The sensitivity of the undiseased eye and cutaneous sensitivity run approximately parallel. In this chart the ocular sensitivity is expressed as the mean of the clinical and histologic reading. Ocular sensitivity appears

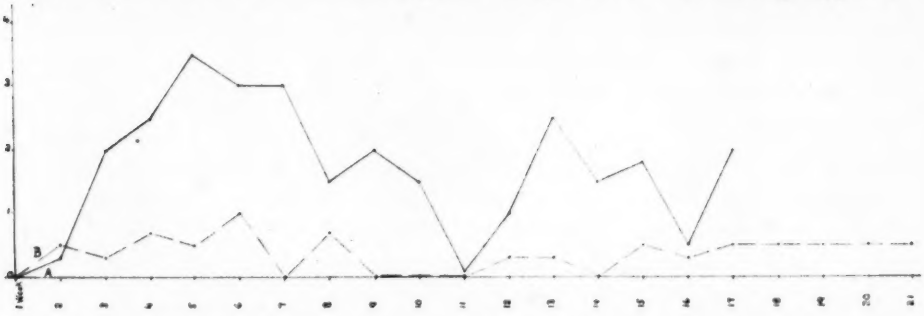


Chart 2.—Curves showing the relation of the cutaneous sensitivity of rabbits inoculated systemically to that of rabbits inoculated by an injection of tubercle bacilli into the anterior chamber. Curve *A* represents the cutaneous sensitivity of the first group, and curve *B*, that of the second group.

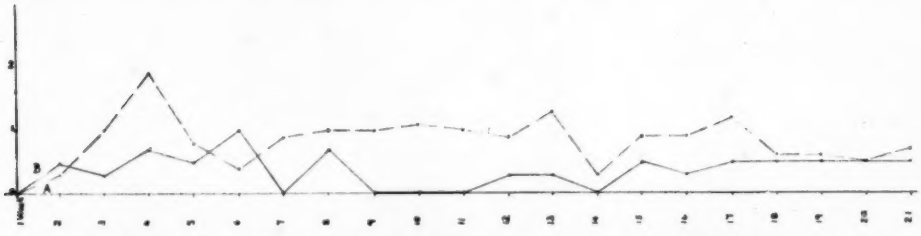


Chart 3.—Curves showing the relation of the ocular sensitivity of the left eye to cutaneous sensitivity after inoculation of the anterior chamber of the right eye with tubercle bacilli. Curve *A* represents the ocular sensitivity, and curve *B*, the cutaneous sensitivity.

to be slightly more marked than does cutaneous sensitivity and less subject to fluctuations. However, although both were charted on the same numerical scale, it is difficult to compare the degree of reaction in such completely different tissues. Certainly, however, the sensitivity of the uninoculated eye, as determined by the injection of purified protein derivative, appears more constant than does the cutaneous sensitivity.

Relation of Sensitivity in the Inoculated Diseased Eye to Cutaneous Sensitivity.—The graphs of ocular sensitivity in the diseased eye and of cutaneous sensitivity are shown in chart 4. The inoculated eye rapidly

became sensitive to tuberculoprotein, and this sensitivity reached a maximum by the fifth week. As before noted, the development of a high degree of ocular sensitivity was accompanied by an acute inflammatory phase of the ocular tuberculosis. Ocular sensitivity remained at a high level for approximately sixteen weeks, when it was neutralized or exhausted by the tuberculous inflammatory process. Thereafter sensitivity fell rapidly, the acute inflammation subsided synchronously and the eye showed evidence of repair and scarring.

Cutaneous sensitivity, on the other hand, was always of low degree. It first appeared about the second week, fluctuated slightly and reached its low maximum about the sixth week, synchronous with the development of the high ocular sensitivity. Thereafter cutaneous sensitivity fluctuated at a low level. At no time did it parallel ocular sensitivity, and certainly at no time during the ocular inflammation did cutaneous sensitivity give any index of the degree of ocular sensitivity.

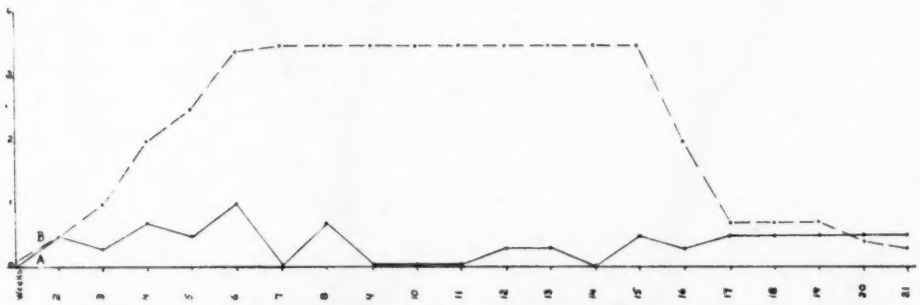


Chart 4.—Curves showing the relation of the ocular sensitivity of the right eye after inoculation of the anterior chamber with tubercle bacilli to cutaneous sensitivity. Curve *A* represents the cutaneous sensitivity, and curve *B*, the ocular sensitivity.

COMMENT

In these normal rabbits which were inoculated intra-ocularly by means of an injection of tubercle bacilli into the anterior chamber of one eye, the ocular tuberculosis and its influence on the development of systemic allergy are reduced to their simplest form. There is no systemic tuberculosis to complicate the picture, and the cutaneous reactions to purified protein derivative must be attributed solely to the ocular disease. Primarily, it is interesting that the degree of cutaneous sensitivity in these rabbits is less than that in the rabbits systemically inoculated. The most probable explanation for this is that less tuberculoprotein diffuses out from the scleral envelop than from a tuberculous focus in the groin. The lower degree of cutaneous sensitivity may therefore be a reflection of the lower stimulus. On the other hand, the smaller initial number of bacilli injected into the eye may be the influencing factor. Against this explanation are the facts that there

was apparently a greater propagation of bacilli in the eye and that the second, uninoculated, eye acquired a degree of sensitivity equal to that in the eyes of the systemically infected rabbits. In any event, the inescapable conclusion is that an active tuberculous focus in the eye alone will not evoke a cutaneous sensitivity of any marked degree.

The constant and well marked sensitivity shown by the uninoculated eye is interesting and brings up the question of organotropism, which has been so widely discussed in relation to ocular tuberculosis and sympathetic ophthalmia. This is a point for further investigation.

These studies are on animals without systemic tuberculosis, the only focus being the result of an injection of tubercle bacilli into the eye. This is obviously a highly artificial condition and in no way parallels the picture of ocular tuberculosis in man, in whom the disease occurs almost invariably in association with systemic infection as a result of hematogenous spread. It is therefore impossible to draw any conclusions of clinical importance, for the results reported here may possibly be reversed when the studies are repeated in systemically infected, or immune-allergic, animals. However, it is of more than passing interest to note that when the ocular tuberculous infection is reduced to its simplest form the degree of cutaneous sensitivity, as determined by the intracutaneous Mantoux test, gives not the slightest indication of the degree of ocular sensitivity. It is also interesting that in the three rabbits noted in the second paper of this series, which showed late exacerbations of tuberculous inflammation, there was an increase in the vascular reactivity of the eye to injections of purified protein derivative but no change or increase in the cutaneous reactivity.

CONCLUSIONS

A local tuberculous focus in the eye of an otherwise normal rabbit produces only a low grade cutaneous sensitivity. This cutaneous sensitivity appears the second week after inoculation and is distinctly less than is observed after systemic inoculation.

The second eye acquires a definite sensitivity to purified protein derivative after inoculation of the fellow eye. This appears to be more constant, and possibly of higher degree, than the cutaneous sensitivity.

There is no relation between the cutaneous sensitivity and the sensitivity of the diseased eye in such a rabbit. Cutaneous sensitivity gives no idea of the degree of ocular sensitivity present.

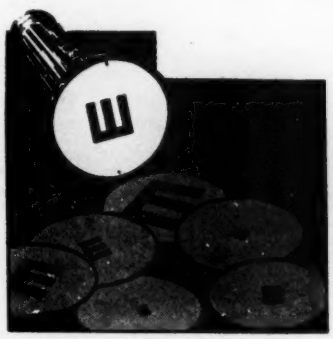
The Mulford Biological Laboratories, Sharp & Dohme, supplied the purified protein derivative used in these tests, and Miss Rosa Himelfarb gave technical assistance.

Clinical Notes

A STANDARDIZED APPARATUS FOR TESTING THE VISUAL ACUITY OF THE PRESCHOOL CHILD

PALMER GOOD, M.D., KENOSHA, WIS.

Increasing demands are being made on oculists and school nurses for the determination of the visual acuity of the preschool child and of the child in the first and second grades. The National Society for the Prevention of Blindness recommends the use of the Snellen E chart for many good reasons, which cannot be explained here, but this chart has the following disadvantages: variability in illumination as it is used in various schools and offices; awkwardness found by the examiner in



Apparatus for testing the visual acuity of the preschool child.

turning from the chart to the child and back again, and inability of many of the younger children to get the idea of change in the direction of the "legs" of the E. A new apparatus was made to retain all the advantages of the Snellen E chart and, in addition, to have the standardized illumination, portability and motion which is required for child psychology and an arrangement such that the examiner can feel the direction of the legs of the E.

The new apparatus has seven interchangeable disks of the 20/15, 20/20, 20/30, 20/40, 20/50, 20/70 and 20/100 sizes, made accurately on washable celluloid to the sizes recommended by Ferree and Rand and transilluminated to give an illumination of 10 foot candles on the surface. The bulb is specially designed to give uniform light, and because of the very low amperage drain on the batteries, it can be used constantly for at least two hours without any variation in the light.

School nurses have reported more rapid and accurate tests in addition to the ability to test the preschool child.

Oculists find it a great help in determining the visual acuity of children and adults with vision of less than 20/50. The usual charts

are easily memorized by such persons and are not made in a sufficient variety of sizes to permit determination of the progress of changes in visual acuity.

With the 20/70 disk it will be found that the distance at which it can be seen is about equal to the distance at which fingers can be counted. The disk, of course, eliminates many of the inaccuracies of the finger-counting test. The vision can then be recorded, for example, as 5/70. The distance from the patient is critical, so that if a patient can just see the direction of the legs of the E at 10 feet (304 cm.), 1 foot (30 cm.) farther prevents recognition. It is the universal visual test because it gives accurate results in the country school, the city school or the oculist's office. It is simple and inexpensive.

Ophthalmologic Review

EDITED BY DR. FRANCIS HEED ADLER

OPHTHALMOLOGY IN AVIATION

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WASHINGTON, D. C.

In order for a pilot to operate any type of aircraft safely and efficiently, his combined visual elements must function in a manner to insure full visual efficiency without undue nervous or muscular stress. He must be able to regain his senses of equilibrium and position quickly when these are confused after rapid gyrations and while he is in positions to which his body is not accustomed.

In the early days of aviation it was thought that a person in order to fly aircraft must possess a mental and physical equipment that functioned in a peculiarly superefficient manner and that only certain persons possessed such equipments. Later, however, it was found that any person mentally and physically normal could learn to fly more or less successfully. Considering, however, the flying equipment and the general knowledge of aviation, the early flier must have possessed a special brand of psychology to permit him to engage in this vocation.

Early in the World War certain physical standards for fliers were adopted, and all persons assigned to flying duty were required to meet these standards. The standards then adopted have been, with few modifications, maintained to the present day. When the United States Department of Commerce assumed supervisory control of commercial aviation in 1926, physical standards for pilots were adopted similar to those for pilots of the armed forces. The two sets of standards differ in some respects, both as to methods of examination and in actual requirements. However, the physical requirements of both branches of aviation are rigid and are scrupulously maintained.

Ocular stress and dependence on the visual, the vestibular and the muscle sense have been somewhat allayed in recent years by the remarkable advances made in the construction of aircraft and in instruments used in flying. When aviation was in its infancy the flier had little

From the Walter Reed General Hospital.
The data given in this paper formed the basis of Instruction Course 244 of the American Academy of Ophthalmology and Otolaryngology, New York, October 1936.

to assist him except his inherent physical and mental equipment, the principal factors of which were his eyes, vestibular apparatus and determination. His ship was equipped with little more than a "joy stick" and rudder bar and he with a pair of ill fitting goggles that reduced his field of binocular fixation to a remarkable degree. The cockpit was open, exposing the pilot to wind, cold and noise. In the modern types of aircraft the pilot is assisted by innumerable flying instruments and a comfortable seat, and in the closed ships he is completely shielded from the elements. In the modern open ships, such as the army pursuit types, he is well or completely shielded. Added to these features are the automatic pilots, radio beams, flying beacons and two way radio communication, all of which relieve the pilot of considerable nervous, physical and mental stress, particularly on long flights and in inclement weather.

As the eyes are of the utmost importance in aviation, the routine ocular examination is searching, particularly so when student pilots are examined. All persons are not equally sensitive to ocular defects, either under normal conditions or while under nervous, mental or ocular stress. One person may tolerate, seemingly with full efficiency and without the slightest discomfort, surprisingly large defects, while another under identical conditions cannot tolerate a defect one quarter as large without the greatest discomfort and without impairment of function. Because of this disparity in tolerance it becomes difficult to evaluate the importance of seemingly trivial defects. Therefore it is necessary, in order to reduce to the minimum the number of persons who may become incapacitated later, that a certain high standard be maintained that is applicable to all.

While ocular efficiency is recognized as being essential to the efficient flier, there are exceptions. There is on record one person who, having lost an eye, not only learned to fly with this defect but became remarkably proficient and internationally famous as a pilot. It is reported that an exceptional amount of training was necessary in order to compensate for his ocular defect. The aforementioned record does not, however, lessen the importance of binocular efficiency. To assume that all persons with monocular vision can become safe and proficient pilots is equal to assuming that all persons afflicted as is Miss Helen Keller can equal her achievements.

While the eyes are of the utmost importance, they constitute only a part of the flier's necessary physical equipment. He must be able to coordinate his muscles, nervous responses and visual and vestibular reactions into a smoothly functioning mechanism in order to be a successful and enduring pilot.

The physical standards for pilots of all types of aircraft and for all types of flying are set forth in regulations laid down by the armed

forces of the United States and by the Department of Commerce. All pilots of aircraft, whether military or commercial, are required to undergo a physical examination every six months. The physical requirements vary somewhat with the type of flying the person is authorized to pursue.

The armed forces recognize three classes of fliers, and the Department of Commerce two general classes.

The classes recognized by the armed forces [1] are as follows:

Class 1. Applicants for heavier and lighter than air training and all undergoing flying training.

Class 2. Rated pilots who do not meet the standards of class 1, but whose training and experience, in the opinion of the Chief of the Branch concerned, are such as to compensate for the lower physical standard of this class.

Class 3. Rated observers who do not meet the standards of class 1 may be qualified physically within class 3 provided the physical standards of this class are met, and provided their training and experience, in the opinion of the Chief of the Branch concerned, are such as to compensate for the lowered physical standard of this class.

The classes recognized by the Department of Commerce [2] are as follows:

The Department of Commerce fliers are classified as commercial and non-commercial. The commercial pilots are classified as student, amateur and private pilots. Besides these main classes of pilots, there are the glider pilots, classified as student, commercial and non-commercial, and lighter than air pilots. Commercial glider and lighter than air pilots are required to pass the same physical tests as are the non-commercial pilots.

While it is required that the eyes function normally in all respects, there are four visual elements that are given especial attention in the examination of all fliers, namely, acuteness of vision, efficiency of the extra-ocular muscles, accuracy in judging distance and discrimination of color. When one or more of these elements are significantly defective the piloting of aircraft becomes a hazardous vocation. In the trained pilot experience may compensate for such inefficiencies, but only to a limited degree. As the efficiency of the aforementioned elements are dependent on and intimately associated with practically all the other elements of vision, color vision excepted, it is necessary that all the elements function in an efficient manner. For this reason the routine examiations cover practically all phases of ocular function.

ACUTENESS OF VISION

As in many other vocations, a high standard of acuteness of vision is necessary in aviation to attain full efficiency in the performance

1. Standards of Physical Examination for Flying, Army Regulations, no. 40-110, Medical Department, United States War Department, 1931.

2. Physical Standards for Air Craft Pilots, United States Department of Commerce, Bureau of Air Commerce, Washington, D. C., Jan. 1, 1936.

of duties to which the person may be assigned. However, in aviation there is an additional importance attached to acuteness of vision. Not only must the flier see objects clearly, but he must be able to locate them accurately as to positions and in their relations to one another. His accuracy in judging distance is dependent, in part, on his acuteness of vision. He must be able to read at a glance his instrument board and finely printed maps, which are located at a distance of about 18 inches (46 cm.) from his eyes. He must be able to determine the character of the terrain when choosing emergency landing fields, i. e., whether or not there are humps, depressions, holes or other obstacles, and these features cannot be recognized quickly and with any degree of accuracy unless vision is acute. The importance of accurate decisions becomes apparent when it is remembered that, flying speed and altitude having been lost, landing frequently must be accomplished regardless of the character of the chosen field. Aside from such factors as those mentioned, there are a multiplicity of conditions and objects that the military pilot must recognize and locate during routine flying and flying on photographic missions, combat details and other duties.

The following visual standards are required by the armed forces:

Class 1. Visual acuity of 20/20 in both eyes without correction.

Class 2. A minimum of 20/30 for each eye.

Class 3. A minimum of 20/40 in either or both eyes provided it can be corrected to 20/20 with glasses for each eye. A visual acuity of 20/50 in either or both eyes may be accepted provided a satisfactory correction is ground in the goggle lenses bringing the vision in each eye to normal and such correction is worn while flying and provided further that such correction does not give an unsatisfactory depth perception.

Near Vision: Accommodation may be considered as within normal limits provided it is not more than 3 diopters below the mean for the examinee's age. For class 1 the examinee will be disqualified if his accommodation falls more than 3 diopters below the mean for his age, but before an examinee is disqualified his accommodation must be taken on three successive days and an average of the three findings taken. Accommodation below 4 diopters disqualifies for class 1 regardless of age. An examinee may be qualified for class 2 if his accommodation falls more than 3 diopters below the mean for his age, provided it is not less than 4 diopters. For classes 2 and 3 examinees are qualified with accommodation below 4 diopters regardless of age, provided they actually wear their correction for near vision while flying, and their correction while worn enables them to read the test card held at 50 cm.

The following visual standards are required by the Department of Commerce:

Transport and limited commercial pilots—20/20 vision or better in each eye separately. Private, amateur and student pilots—20/50 or better in each eye separately. If the vision in either or both eyes is poorer than 20/50 but is brought to 20/30 or better in each eye by glasses, the applicant may be qualified with the restriction that corrective lenses be worn while operating air craft.

Near Vision. Limited commercial and transport pilots should be required to read type 2 D, Jaeger, or its equivalent, or smaller without correction. If the applicant has a vision of less than 20/20, his accommodation may be tested while wearing his glasses or goggles, provided they have his correction in them.

In the armed forces all applicants for training in flying are subjected to a refraction with the use of a cycloplegic in determining the refractive state. The Department of Commerce does not require this as a routine.

An applicant in order to qualify for flying training, must read, with accommodation paralyzed, 20/20 with not more than one diopter of correction in any meridian, whether hyperopic or myopic and not more than 0.50 diopter of cylindrical correction in any meridian. Any candidate with more than 4 prism diopters of esophoria will be disqualified if he has a hyperopia requiring more than 1 diopter of true correction.

While only applicants for training in flying are subjected to refraction as a routine, any flier may be subjected to this examination should it be deemed necessary.

EFFICIENCY OF THE EXTRA-OCULAR MUSCLES AND BINOCULAR SINGLE VISION

Binocular single vision must be maintained while flying, as it must in many other vocations, and it must be maintained in all directions of gaze without undue nervous or muscular stress. The field of binocular fixation is not large when the standard flying goggle is worn. A composite field (fig. 1) constructed from the results of examination of fifty flying cadets [3] shows the binocular field of fixation with this goggle to be slightly more than 20 degrees, extending to 30 degrees in the inferior field. It is evident that this field is sufficiently large for safe and efficient flying, as the greater part of the flying performed the last few years has been with this or a similar type of goggle. Furthermore, Friedenwald [4] has shown that 20 degrees is about the limit of the binocular field utilized by a person under usual circumstances.

Binocular single vision cannot be maintained without ocular stress unless the extra-ocular muscles and fusion control function efficiently. The phoria [5] is the most common functional defect encountered in the examination of rated and prospective fliers, and reduced power of convergence is the second most common defect.

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3. Simpson: Outline of Examination of the Eye, School of Aviation Medicine, Randolph Field, Texas, 1935, p. 30.

4. Friedenwald, J. S.: Diagnosis and Treatment of Anisophoria, Arch. Ophth. **15**:283 (Feb.) 1936.

5. Thorne, F. H.: A Review of Ocular Muscle Imbalance, Mil. Surgeon **66**: 175 (Feb.) 1930.

When binocular single vision is maintained with effort, either conscious or unconscious, and fixation objects are constantly changing, there is likely to be a slight "wandering off" of one eye from the object fixed, the deviation occurring being insufficient to induce pathologic diplopia but sufficient to stimulate areas of the retina not exactly corresponding. This wandering off of one eye alters physiologic diplopia sufficiently to reduce acuteness of depth perception. Maintaining binocular single vision under the conditions just mentioned induces muscular and fusion fatigue, thereby making binocular single vision

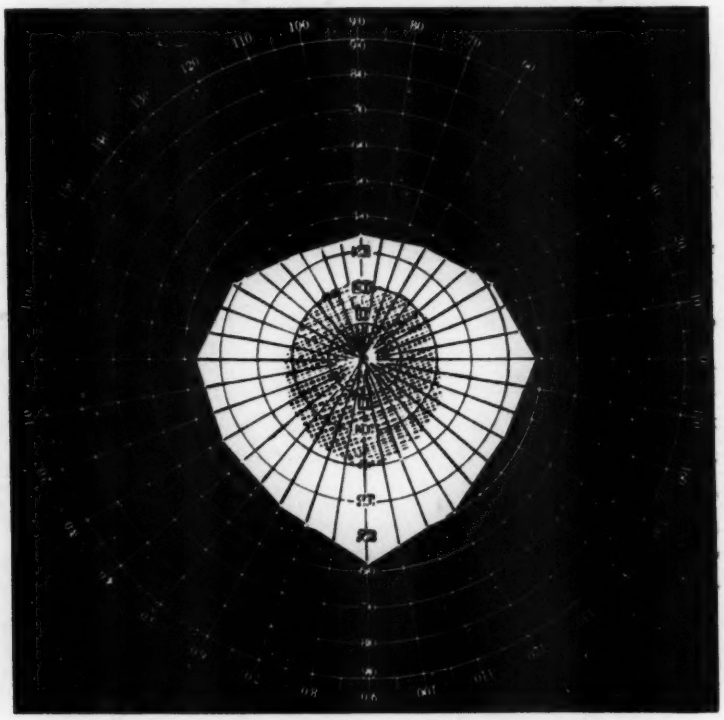

Fig. 1.—Composite field of binocular vision of fifty cadets, showing concentric constriction when a flying goggle (B-6) is worn. The white area shows the normal field, the shaded area, the field when the goggles are worn. Taken from Simpson.[3]

increasingly difficult. This is particularly true when the person is working under a nervous strain. Furthermore, as a person grows older a latent imbalance may become more and more difficult to tolerate.[6]

Regulations require that the efficiency of the ocular muscles be investigated in all cases. The presence of a phoria, the power of con-

6. Davis, W. T.: Esophoria and Exophoria as a Cause of Obstinate Asthenopia; Cure by Surgical and Other Means, Arch. Ophth. **10**:455 (Oct.) 1933.

vergence (angle of convergence), the power of divergence, associated parallel movements and the presence or absence of diplopia, with fusion abolished, when a phoria above a certain degree has been uncovered, are investigated as a routine.

In the armed forces the horizontal and the vertical muscular balance are investigated with the eyes in the primary position, at 6 meters, and the horizontal muscular balance is tested with the eyes in the same position, at 33 cm. When a phoria above a given degree is uncovered at 6 meters the action of the muscles with the eyes directed in each of the eight cardinal positions is then investigated on the tangent screen, at a distance of 75 cm.

The Department of Commerce investigates the muscular balance with the eyes in the primary position and directed in each of the eight cardinal positions, at 6 meters, as a routine in all cases. Investigations indicate that a phoria occurring with the eyes directed in one or more of the cardinal positions, within 20 degrees, is just as important as a phoria occurring with the eyes directed in the primary position.

The requirements of the armed forces are as follows:

Esophoria of more than 10 prism diopters disqualifies without further consideration. An esophoria of more than 4 prism diopters disqualifies when associated with diplopia on the tangent curtain at 75 centimeters, or when more than 1 diopter of hyperopia of true correction is found.

Exophoria of more than 5 prism diopters disqualifies without further consideration. Exophoria of more than 2 prism diopters disqualifies if associated with an angle of convergence of less than 50 degrees or if associated with diplopia on the tangent curtain. Exophoria of more than 12 prism diopters, at 33 centimeters disqualifies.

Hyperphoria of more than 0.5 prism diopter disqualifies for class 1 without further consideration. Hyperphoria of more than 1 prism diopter disqualifies for class 2 without further consideration. 1.5 prism diopters of hyperphoria is permitted for class 3 provided there is no diplopia on the tangent curtain.

Power of divergence of more than 9 prism diopters disqualifies if associated with an angle of convergence of less than 50 degrees. A prism divergence of more than 15 or less than 4 prism diopters disqualifies for all classes without further evidence.

Associated parallel movements. The under action or over action of any of the extrinsic ocular muscles producing a diplopia, except in the extreme positions, disqualifies for all classes.

An angle of convergence of less than 50 degrees disqualifies for all classes if it is associated with a hyperopia requiring a true correction of more than 1 diopter or if associated with a prism divergence of more than 9 prism diopters. An angle of convergence of less than 40 degrees disqualifies for all three classes.

The qualifications of the Department of Commerce are as follows:

Diplopia test. Diplopia occurring in any position of gaze (red lens before one eye) within 45 degrees disqualifies for any class of license. If correcting lenses are worn the test is made with and without his glasses. If a diplopia disappears with the correcting lenses the examinee is not disqualified for a non-commercial license.

Hyperphoria. A prism diopter of more than 1 disqualifies as a transport or limited commercial pilot. Not used to disqualify for non-commercial grades.

Duction. Abduction (prism divergence) of 3 diopters is required. More than 3 diopters may be accepted, provided the amount of adduction is increased in proportion.

Adduction of 8 prism diopters or more is satisfactory provided there is an abduction of not less than 3 diopters. Duction tests are not used to disqualify for non-commercial grades.

DEPTH PERCEPTION

Depth perception [7] is an element of vision that must function efficiently if the pilot is to continue flying and retain his health. In importance it must be considered as equal to acuteness of vision. It is this element of vision that enables the flier to level off his ship at the proper distance from the ground when making landings; to take off with the necessary margin of safety over trees, buildings, fences and other obstructions, and to fly in close formations and take part in aerial combat when engagement of enemy ships at close quarters is necessary.

Early in aviation a test of stereoscopic vision, made with an ordinary parlor stereoscope, was considered sufficient to determine whether or not a person possessed ability to judge distance accurately. The aforementioned type of stereoscope utilizes one of the visual elements concerned in the judgment of distance, namely, binocular single vision. Psychic fusion of the two ocular images, which are not identical, is demonstrated by creating an optical illusion, giving rise to an impression of depth where depth does not actually exist. This device, therefore, offers no information regarding actual depth, and it was soon replaced by a device wherein all the inherent or basic elements involved in perception of depth are utilized.

Theory of Depth Perception.—There are many factors involved in depth perception. With some of these factors ophthalmologists are, at least theoretically, familiar, while undoubtedly there are many factors involved of which they are totally ignorant. Some of the known factors constitute a part of the physical and psychic equipment of the individual; they are constant and when considered together may be termed inherent depth perception.[8] Other factors involved exist outside the body; they are common to all persons; they are variable, and they operate independently of the individual. These factors may be referred to as adjunct factors utilized to enhance the already existing inherent sense.

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7. Howard: A Test for the Judgment of Distance, Air Medical Service Information Circular, United States Army, March 15, 1920, pp. 99-115.

8. Thorne, F. H.: A Review of Depth Perception, Mil. Surgeon **63**:643 (Nov.) 1928.

The visual elements that go to make inherent depth perception are: (1) acuteness of vision, (2) binocular single vision, (3) physiologic diplopia, (4) binocular parallax, (5) accommodation and (6) convergence.

The adjunct factors that may be utilized are: (1) the size of the retinal image; (2) motion parallax (movements of the head or the object); (3) terrestrial association, consisting of (*a*) linear perspective, (*b*) overlapping of contours and (*c*) light, reflections and shadows; (4) aerial perspective, i. e., the changes with respect to color, brightness and contrast which different objects undergo on account of variations in the clarity of the intervening atmosphere, and (5) experience.

Some of the factors operating to constitute depth perception are common to monocular and binocular single vision alike, while others pertain to binocular single vision only. The factors common to monocular and binocular single vision are: (1) acuteness of vision, (2) the size of the retinal image, (3) accommodation, (4) motion parallax, (5) terrestrial association and (6) aerial perspective. The factors operating with binocular single vision only are: (1) physiologic diplopia, (2) binocular parallax and (3) convergence.

In applying a test to determine a person's accuracy in judging distance it is necessary to utilize only those factors which operate to make for an individual difference in ability, namely, the inherent factors. What a person may gain through experience and that which he may utilize, aside from his inherent equipment, should be left to the subject concerned and to his instructors.

In order to accomplish this the method employed must eliminate all external assistance that experience has taught the subject to employ. For instance, motion parallax is produced either by movements of the person or of objects within his field of vision. For that reason it may be considered as an artificial factor employed to enhance the already existing faculty. It should, therefore, be eliminated as a factor related neither to inherent nor to acquired ability.

External factors which assist all persons equally, such as terrestrial association and aerial perspective, should be eliminated for the same reason.

Factors which normally operate only at a distance of less than 6 meters, such as accommodation, do not need to be considered ordinarily, but accommodation may play an important part when the normal balance between convergence and accommodation does not exist. Fliers are not, as a rule, called on to form judgments at distances of less than 6 meters.

When all external factors and those operating at distances of less than 6 meters are eliminated the following remain to be considered: (1) the size of the retinal image, (2) physiologic diplopia, (3) binocular parallax and (4) convergence.

Size of the Retinal Image.—When dealing with familiar objects the observer knows, through experience, their apparent size. When such objects appear small the observer gains the impression that they are remotely situated in relation to himself, and when they appear larger he has the impression that they are nearer. When one observes two objects that experience teaches are of equal size and one appears smaller than the other the impression is immediately conveyed that the smaller is the more remote of the two, but on this factor alone the actual distance cannot be determined with any degree of accuracy.

Actual tests indicate that in determining distances between objects accuracy is many times greater with two eyes than with one. Deyo[9] demonstrated that with one eye covered the normal person can distinguish a separation of two posts, one in front of the other, when the average distance apart is 120 mm., but with binocular vision an average distance of 20 mm. can be detected.

In monocular vision binocular parallax, convergence and physiologic diplopia are eliminated. Therefore monocular judgments must depend on the size of the retinal image alone, and such judgments are not particularly accurate.

Since depth perception is many times less accurate when the decision depends on the size of the retinal image alone, it follows that other inherent factors play an important part, and these factors must be physiologic diplopia, binocular parallax and convergence.

Physiologic Diplopia.—The faculty of recognizing differences in distance between objects which are located in space and within one's visual fields is founded, in part, on physiologic diplopia, although a conscious diplopia is suppressed. When the eyes fix an object (binocular fixation) the image of that object falls on the macula of each retina. The two images are fused and projected into space, and one sees the object at the place where the visual lines cross, which is the place actually occupied by the object fixed. The image of another object within the visual fields, located at a greater or lesser distance than the object fixed, falls on the retinas at points outside of the maculae. When the second image falls on the nasal side of the macula of the right eye it is projected to the temporal field, and the image of the object is located to the right of the point actually occupied by the real object and at a distance equal to the distance between its point of contact on the retina and the macula. When the image falls on the temporal side of the macula it is projected to the nasal field and is located in the same manner. The same applies to the left eye. When these retinal points do not correspond, psychic fusion of the two images does not occur, and physiologic

9. Deyo, B. V.: Judgment of Distance: Monocular and Binocular Judgment of Distance, Am. J. Ophth. **5**:343 (May) 1922.

diplopia results; but when the retinal points correspond, psychic fusion of the two images occurs, and physiologic diplopia does not result. Two objects are located within the field of vision, and but two images are projected. The image or images of the nonfixed object are not to be confused with that of the object fixed. The object fixed appears as one and in its proper position.

Objects located nearer than the object fixed give rise to crossed diplopia, and those more remote than the object fixed give rise to homonymous diplopia. It is because of this crossed and homonymous diplopia that one gains the impression that objects are nearer or farther away, in relation to other objects and oneself. The threshold sensitivity relative to disparate points is very low, about 10 seconds of arc.[10] It may be said, in general, that images falling on disparate points of the retinas, which are located nasally to the corresponding points, give rise to an impression of remoteness, while those falling temporally give rise to an impression of nearness. The greater the disparity the greater will be the distance.

Binocular Parallax.—While one perceives, through physiologic diplopia and the size of the retinal image, the existence of differences in distance between objects and oneself, the binocular parallax augments this perception by giving rise to the impression of relief and solidity.

When one fixes an object the right and the left eye obtain somewhat different views of that object. The right eye sees a little farther around the object to the right, and the left eye a little farther around it to the left. This gives rise to two ocular images that are not exactly alike. When these images are fused in the cerebrum the disparity is responded to by an impression of relief and solidity.

Inherent depth perception, therefore, apparently depends on the following factors: (*a*) physiologic diplopia, which creates the impression, and suggests the amount, of depth, where depth actually exists, and (*b*) binocular parallax—psychic fusion of two slightly different ocular images, which gives rise to the impression of relief and solidity, thereby augmenting the impression of depth gained by physiologic diplopia.

Adjunct Factors.—The secondary factors which enhance one's inherent perception of depth, with the exception of motion parallax, exist and operate independently of the person. When utilized they are probably of as much importance as are the inherent factors.

Primarily man is equipped with the basic or inherent factors for forming judgments, and one soon learns, through experience, to utilize all other assistance that comes to hand. However, if these basic factors do not function efficiently, the value of all external assistance that may

10. Ames, A.: Aniseikonia—A Factor in the Functioning of Vision, Am. J. Ophth. **18**:1014 (Nov.) 1935.

be available is proportionally reduced, because one does not know how to employ it. Because of this it is necessary to determine the degree of efficiency with which the basic factors function.

Equipped with a normal foundation for judging distance, the student soon learns, in his new environment in the air, to utilize all external assistance peculiar to flying.

After one becomes experienced in flying one may be deprived of all the basic factors, with the exception of the size of the retinal image, and still be able to judge distance sufficiently accurately to land a ship. This is particularly true when one is familiar with the ship, the terrain and other factors. This fact has been demonstrated with experienced fliers who have been deprived of the use of one eye temporarily. At first some difficulty is experienced, but this is soon overcome to a great extent. Their ability to continue flying is due to the fact that flying, landing and other maneuvers have become partially mechanical and subconscious, and they have learned from experience how to utilize all external assistance to the utmost. However, these persons never regain the fine precision and sense of sureness in flying that they enjoyed previously.

Measuring the Accuracy of Depth Perception.—When one perceives a difference in distance between objects, one's conception of the amount of difference may be accurate, or it may be decidedly inaccurate. It is, therefore, desirable to determine the degree of accuracy one possesses; this is accomplished by utilizing the binocular parallactic angle (fig. 2).

The depth perception box of Howard (fig. 3), employed to measure the binocular parallactic angle, is designed to utilize principally those factors belonging to the basic group. All external factors, with the exception of the size of the retinal image, which usually operate to assist in judging distances are eliminated. The examinee views two posts of equal size, 64 mm. apart laterally and at unequal distances from him (fig. 4). One post is stationary, while the other can be moved forward or backward by the examinee by means of a cord attached to the movable post. The apparent size of the objects and the subject's physiologic diplopia, his binocular parallax and, in some instances, his convergence tell him that a depth difference exists between the two objects. It is the examinee's task to eliminate this difference, i. e., to place the two posts at equal distances from him. The average accuracy with which this is accomplished determines his inherent degree of ability to judge distance.

Etiology of Defective Depth Perception.—Several factors may operate to render depth perception inaccurate. These factors may operate separately or together, and judgment may be consistently poor, or it may be erratic.

Defective vision reduces the accuracy of depth perception for the simple reason that objects and surfaces are not sharply outlined, and physiologic diplopia is partially or completely abolished, depending on the degree to which vision is reduced. The more vision is reduced the more inaccurate judgments will be. When vision is reduced in one eye only, a status of monocular vision is approached, and monocular judgment is very poor, as decisions are based on the size of the retinal image.

Errors in Refraction.—When hyperopic errors in refraction are exhibited—an error of 1 D., for instance—and the examinee maintains

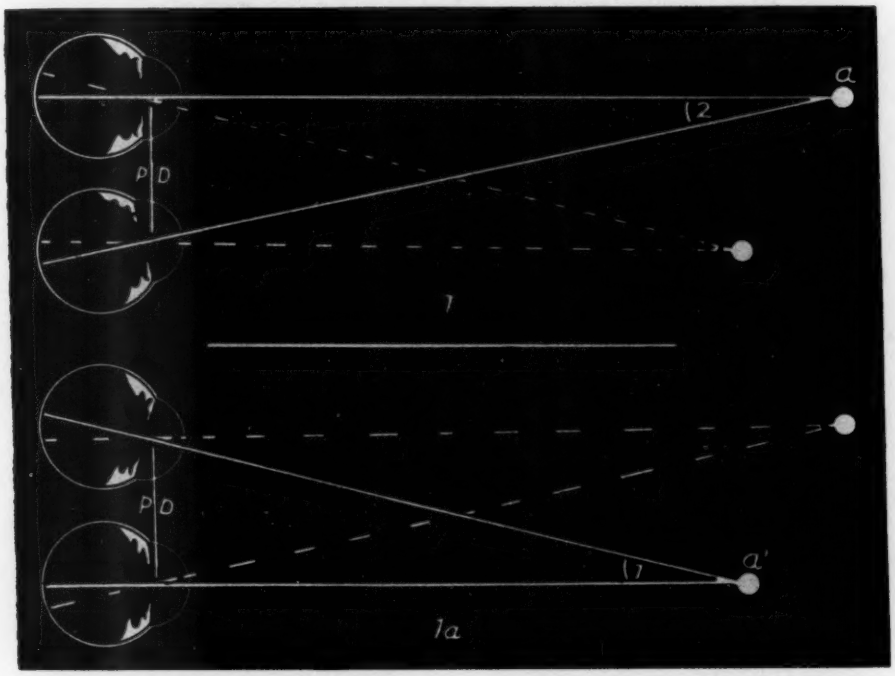

Fig. 2.—Diagrammatic illustration of the binocular parallactic angle. The fixation objects *a* and *a'* are arranged as in the Howard depth perception box. *1* shows the eyes fixing the far object *a*. The visual lines crossing at this object form the angle *2*. *1a* shows the visual lines fixing the near object *a'*. The lines crossing at this object form the angle *1*. Angle *1* minus angle *2* equals the difference in depth, or the binocular parallactic angle. *PD* indicates the interpupillary distance.

visual acuity of 20/20, he is doing so by accommodating 1 D. in excess of the normal. He is, however, at the same time converging only the normal amount for the distance fixed, which is nearly nil for infinity. This state introduces an imbalance between convergence and accommodation. When the eyes have to accommodate 1 D. to maintain vision of 20/20 they should, at the same time, converge 1 meter angle in order

to effect a balance between these two factors. If a balance were attained under the conditions just described, the image would be out of focus, as the visual lines would cross at a distance of 1 meter instead of at the point in space occupied by the object. Therefore, in order to converge and accommodate accurately in fixing the object the lateral rectus muscles must exert sufficient pull to offset the natural urge to converge. The excess of nervous energy expended in maintaining this imbalance is interpreted, psychologically, into distance, and objects within the visual field will appear at a greater or lesser distance as the case may be. Even

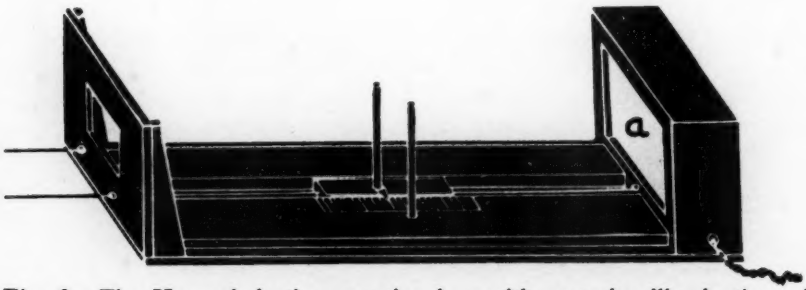

Fig. 3.—The Howard depth perception box with posterior illumination. The bulb in the cabinet (*a*) should give illumination equal to 8 foot candles at the stationary post.

Fig. 4.—The test objects of the Howard depth perception box as seen by the examinee at a distance of 6 meters.

the fixed object may be inaccurately placed. A similar psychic impression is gained in gazing at vertical and horizontal stripes. Clothing with vertical stripes makes the wearer appear taller, while that with horizontal stripes makes him appear shorter—a greater amount of nervous energy being expended in vertical than in horizontal rotation of the eyes.

In the myope this imbalance is not so marked, because there is no accommodation for distance, and the convergence required to cross the visual lines at an object located in infinity cannot be great.

Imbalance of Ocular Muscles.—When it becomes necessary to innervate one extrinsic ocular muscle to a greater degree than another in order

to maintain binocular single vision, the resulting binocular single vision is not very stable, and the instability is increased by fatigue and relaxation of attention. The "wandering off" of one eye, referred to in the section "Efficiency of the Extra-Ocular Muscles and Binocular Single Vision," permits stimulation of cones in the wavering retina that are not identical with those stimulated in the master eye. This stimulation of disparate cones is not necessarily sufficient to cause pathologic diplopia, but it is sufficient to induce disruption of the physiologic diplopia and to cause some blurring of the object fixed. As the retina is very sensitive in regard to stimulation of disparate points, a slight disparity immediately affects one's ability to interpret distances accurately. Then there is the excess of nervous energy utilized by one or more of the extrinsic ocular muscles in maintaining parallel visual lines. This excess of nerve energy is interpreted into distance, as it is in reference to accommodation and convergence.

Asymmetry of the Ocular Images[10].—Normally the two ocular images are of equal size and, other things being equal, can be fused by the cerebral centers into one image giving the impression of relief and solidity. However, it has been shown that equality of the ocular images does not always exist and that they may be of unequal size or vary as to shape or both. Asymmetry may range from aniseikonia of the least measurable amount (0.25 per cent) to the manifest type encountered in unilateral aphakia (35 per cent). In squint, anisometropia and other disorders the difference in size ranges from 5 to 15 per cent. Ocular images with a difference in size or shape up to 5 per cent can be fused, but any difference above 1 per cent is likely to cause symptoms. When the asymmetry is over 5 per cent, binocular single vision does not occur, and one image is superimposed on the other, or there is diplopia. It has been demonstrated many times that a person with unilateral aphakia and vision corrected to 20/20 bilaterally cannot judge distance sufficiently well to pass the depth perception test of Howard. Ames[10] has demonstrated, with his tilting field device, that a person with a low percentage of aniseikonia cannot level the tilting field until his aniseikonia has been corrected. When aniseikonia exists accurate binocular single vision cannot be attained, because exactly corresponding points of the retina are not stimulated. Aniseikonia, therefore, reduces the accuracy of depth perception because neither binocular parallax nor physiologic diplopia function accurately, and these two factors are important visual elements concerned in depth perception.

The factors involved in the test with the tilting field device differ somewhat from those involved in the test with the Howard depth perception box. In the test with the tilting field the observer sees only the field with one eye, while with the other he sees the field and the

frame surrounding it. In the test with the depth perception box of Howard the observer sees the same objects with each eye, namely, the screen with its aperature and two vertical posts.

The requirements of the armed forces are as follows:

For class 1, a depth perception of not more than 25 millimeters (9.119 seconds of arc) disqualifies. For class 2 and for class 3, a depth perception of more than 30 millimeters disqualifies. A rated observer examined for class 3, if he wears correcting glasses or goggles while flying, must have his depth perception tested both with and without his glasses or goggles because corrective lenses not infrequently interfere with depth perception.

The Department of Commerce has established the following qualifications:

A depth perception of not more than 30 millimeters, without correcting glasses, on the average of all trials is required for all classes of pilots with the sole exception of certain private, amateur or student pilots as described herein. If the average is more than 30 millimeters without glasses but is not more than 30 millimeters with glasses, applicants for, or holders of, private, amateur or student license may be qualified with the restriction that correcting lenses be worn while operating air-craft.

COLOR VISION

Accurate and rapid discrimination of colors becomes important to the flier when selecting emergency landing fields, recognizing colored signal lights, navigation lights, lights denoting the limits of landing fields, and daylight panels, and in reading colored maps. In selecting landing fields the character of the terrain may be determined to an important degree by its color. The color presented enables the flier to determine whether the selected field is dry, swampy, newly plowed or covered with stubble and many other facts of importance. The rapid and accurate recognition of colors attains its maximum efficiency in the hexachromic person. A person to whom the spectrum appears to contain less than six bands or in whom one or more of the bands deviate from the normal cannot be relied on under all circumstances, as is necessary in aviation.

An aviator may be defective in his discrimination of colors and fly with comparative safety so long as he is flying over terrain and in and out of fields with which he is familiar. However, when he enters unfamiliar territory, when ground panels, colored signals and other devices are resorted to, he is likely to fall into grave difficulties. Therefore, it cannot be considered safe for a pilot with defective color vision to assume responsibility for aircraft flight, because emergencies frequently arise, and pilots may be called upon at any time to fly over unfamiliar terrain, in and out of strange landing fields and in rain and fog.

To determine accurately the type of color defective with which one is dealing is a slow and tedious undertaking. In the Army Air Corps, when physical examinations of candidates are made this invariably means that large numbers are to be examined and the examinations are to be completed in a short period. Consequently, the time alloted to each candidate must be brief.

The notation "color ignorant" or a similar statement, appearing in a report of examination, indicates that the examinee is invariably defective in perception of colors and the examiner unfamiliar with the subject of color vision. Any person possessing sufficient intelligence to be authorized to appear before an examining board is never ignorant of the colors red and green unless his perception of colors is defective. An examinee may be stumped if asked to select such colors as mauve and cerise, but such colors are not employed in the standard tests. In the properly conducted test colors are not referred to by name in any case.

In order for an examiner to investigate and report intelligently on a person with defective color sense he should possess some knowledge of colors; he should know the theoretical content of the spectrum, characteristic of the various types of color defectives, and by the examinee's selection of colors he should be able to classify him accordingly.

In the army considerable difficulty has been experienced in determining and reporting in just what respect examinees are defective in their discrimination of colors. Embarrassing situations have developed in reporting candidates for the Army Air Corps and the West Point Military Academy as possessing normal color vision who were definitely defective and, again, those who were normal as being defective. Sometimes these errors are made because the examiner is unfamiliar with the theories of defective color vision and why certain confusions are exhibited in matching colors, because of insufficient time in which to conduct the test or, not infrequently, because the candidate has memorized the test plates. In order to alleviate this troublesome phase of physical examination Cooley and Grow [11] published an outline of the evolution of color vision, the types of defectives encountered, the confusions exhibited by the various types in matching colors and the reasons therefor. This work is based on the Edridge-Green theory of the evolution of the color sense and classification of defectives. The classification and the reactions exhibited by the different types are explained, and if these factors are kept in mind by the examiner a reliable solution of the problem is available. This method at least meets the urgent needs of the Army, as it offers a uniformity in respect to the diagnosis of defective color vision that has not heretofore existed.

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11. Cooley, E. E., and Grow, M. C.: Color Vision, Army M. Bull., January 1936, no. 34, pp. 1-31.

A brief outline of the theory of the evolution of color vision and the types of defectives encountered follows:

Color vision is a psychophysical process, the physical component being the light waves that go to form the visible solar spectrum, and the psychic component the sensations aroused by the action of these waves on the sensory organ of vision. As one is dealing with a person's sensations, the determination of the content of the spectrum as seen by color defectives and any method of classification must be theoretical, in part, at least, as it is impossible to illustrate in a concrete manner another's sensations.

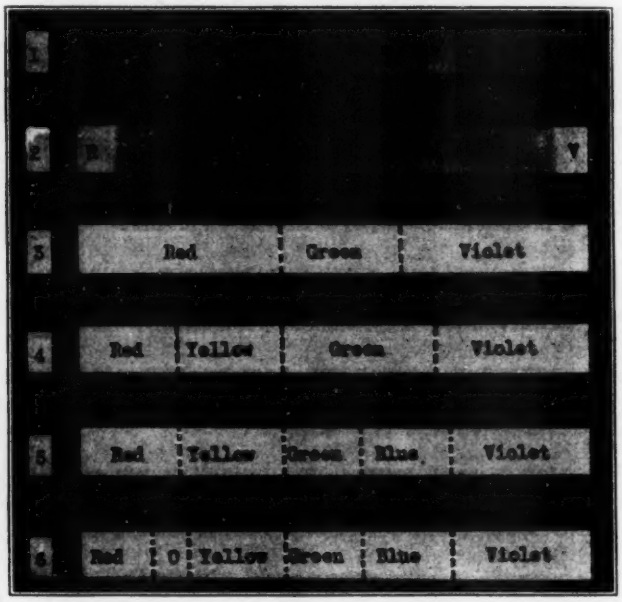


Fig. 5.—Chart illustrating the theoretical evolution of color vision. *1* represents achromism, or the state of the primitive eye, in which the entire spectrum is black or gray. *2* represents the first stage of color vision, in which there is perception of red at one end of the spectrum and perception of violet at the other end, the remainder of the spectrum being black or gray. *3* represents the second stage, or trichromism, in which there is perception of three colors occupying the entire spectrum. *4* represents the third stage, or tetrachromism, in which there is perception of four colors. *5* represents the fourth stage, or pentachromism, in which there is perception of five colors. *6* represents the fifth stage, or hexachromism, in which there is perception of six colors.

Early in the process of evolution the primitive eye could distinguish light and shade, depending on the intensity of the stimulus (fig. 5, 1). The first stage of color perception was ushered in by the recognition of a tinge of red at the left end of the spectrum and a tinge of violet at the right end, the intervening space being black or gray (fig. 5, 2).

In the second stage color vision had increased until the entire spectrum was composed of three colors, namely, red, green and violet (fig. 5, 3). In the third stage yellow was distinguishable between red and green (fig. 5, 4). In the fourth stage blue was distinguishable between green and violet (fig. 5, 5), and in the fifth stage orange was distinguishable between red and yellow (fig. 5, 6). Occasionally another stage is seen wherein indigo is distinguishable as a distinct color between blue and violet. In these cases the entire spectrum is brightened and the discrimination of colors is very acute.

The solar spectrum, therefore, to the person with a fully developed sense of color discrimination, consists of six bands of color of unequal length, each band merging by fine gradations into the adjacent band or bands. The colors, reading from left to right, are red, orange, yellow, green, blue and violet. The six band, or normal, spectrum, is seen by about 80 per cent of the entire population. The spectrum to the remaining 20 per cent is either composed of less than six bands or one or more of the six bands deviate from the normal in one respect or another. The defect is congenital in about 10 or 12 per cent and acquired in the remainder. However, only about 3 per cent of the population are sufficiently defective in color perception to be of any great significance. As acquired defects are usually manifestations of underlying pathologic processes, they will not be considered in this discussion.

Classification and Detection of Color Defectives.—Congenital defective color vision is atavistic in character, and the reversion may be complete, as in the achromic person, or it may involve certain colors or bands of the spectrum only. Furthermore, the colors for which the subject has defective vision may be involved to varying moderate degrees, or they may be completely obliterated and replaced by others. In any case, the spectrum as seen by the subject forms the basis on which he reacts to the various colors, and a classification is made accordingly. If in all cases of defective color vision the involved bands were completely devoid of color or the normal colors were completely replaced by others, the detection and classification of the subject would be a relatively simple matter. The various classifications of defective color vision are based on the spectrum as seen by the subject and are outlined in the following paragraphs.

Space is insufficient in this review to attempt to cover the numerous responses to colors exhibited by the various defectives. Therefore remarks will be confined to those reactions that may be termed basic.

Hexachromism—Normal Color Vision (fig. 6, 1).—Persons falling into this classification see and respond accurately to the colors of the spectrum. In the examination they are prompt and accurate when

matching colors and reading the Ishihara plates.[12] They do not see figures 5 and 2 in the Ishihara plates 10 and 11, and they cannot trace a continuous line from *x* to *x* in plate 16.

Pentachromism (fig. 6, 2).—The pentachromic person is the first type in the reversion to the primitive. This person distinguishes five colors in the spectrum. Orange is not seen, and its area is occupied by red and yellow, red encroaching on this area to a greater extent

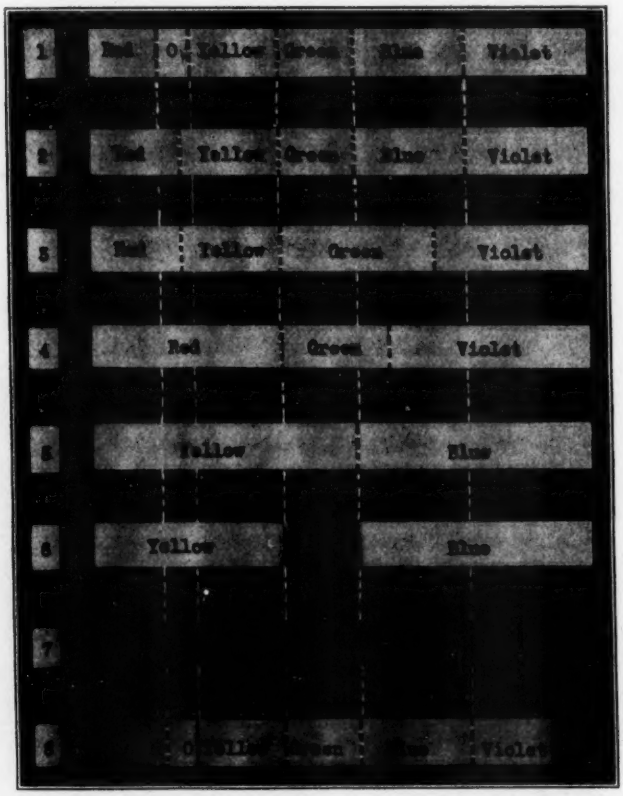


Fig. 6.—Chart illustrating the spectrum as it is seen by persons in the various types of congenital defective color vision (based on Cooley and Grow's paper). *1* represents hexachromism, or normal color vision; *2*, pentachromism; *3*, tetrachromism, and *4*, trichromism. *5* represents dichromism, the ordinary color blindness for red and green most commonly detected in routine examinations. *6* represents dichromism with a neutral band centered in the area occupied by the green band in the normal spectum. *7* represents achromism, the entire spectrum being gray. *8* represents shortening of both ends of the spectrum; the spectrum is normal otherwise.

than yellow. Orange is recognized as a shade of red or yellow, and brown, being a dark shade of orange, is confused with red or yellow.

12. Ishihara, S.: Tests for Color Blindness, ed. 6, Chicago, C. H. Stoelting Company, 1932.

About 6 per cent of the population belong in this classification. The defect is rarely detected in the routine tests of color vision. In the Army Air Corps many planes, landing tees and wind stocking are painted a shade of orange.

Tetrachromism (fig. 6, 3).—The tetrachromic person sees four colors in the spectrum, orange and blue being lost and that part of the spectrum normally seen as blue being occupied by green and violet. Yellow and red occupy the orange band, as in pentachromism. The green band has encroached on the blue band, and blue is recognized, therefore, as a shade of green. Blue is chosen with green, and brown and orange with red or yellow. About 3 per cent of the population belong in this classification.

Trichromism (fig. 6, 4).—The trichromic person sees three colors in the spectrum. He does not see orange, yellow or blue, and the orange and yellow bands are occupied by the red band. Again, the green band encroaches a good distance on the blue band, but not so far as does the violet band. Yellow, orange and brown are seen as shades of red, and blue is seen as a shade of green or violet. About 1 per cent of the population belong in this class.

Dichromism (fig. 6, 5).—The dichromic person is the type with defective color vision for red and green who is most commonly detected in routine tests for color vision. In this type of defective the spectrum consists of two colors, namely, yellow and blue, and the junction of these is centered in the area normally green. This type of color defect has many variations. Investigations indicate that in one type of dichromism the spectrum consists of green and blue instead of yellow and blue. In the yellow-blue part of the spectrum red, orange and shades of green are recognized as shades of yellow, and violet and shades of green as shades of blue. About 2 per cent of the population belong in this classification.

Achromism (fig. 6, 7).—This type of person is rare. The entire spectrum is devoid of color and appears as black or gray, depending on the illumination. Central vision is poor; intolerance to light may be marked, and nystagmus may be present. This type never appears before aeronautic examining boards because of the manifest ocular defects.

Shortened Spectrum and Neutral Band (fig. 6, 6 to 9).—In addition to the aforementioned deviations from the normal, the spectrum may be shortened at one or both ends, and such defects may encroach a short distance or entirely on the red and violet bands. These areas then appear black or gray. When such an area appears in the body of the spectrum it is referred to as a neutral band and is centered in the green part. Shortening of one or both ends of the spectrum may occur in

any type of spectrum, but a neutral band appears to be found only in dichromism. In this condition a neutral band may expand until it occupies the greater part of the spectrum, only a narrow band of yellow being left at one end and a similar band of blue at the other. A shortened violet end of the spectrum may be of no particular importance, but a shortened red end and a neutral band are serious defects.

A shortened red end of the spectrum is detected when the examinee selects grays with reds. The color red coming from the shortened area of the red band does not exist for the subject. To him that shade of red is gray. The seriousness of this defect becomes apparent in aviation when it is remembered that the most penetrating red rays available, i. e., those rays from the extreme left of the red band, are utilized in red signal lights, and it is this part of the band that is involved in shortening of the spectrum. Red signal lights contain green rays as well as red rays. Consequently, when such a light is viewed through fog or smoke, any of the red rays that may be ordinarily perceptible to this type of defective are obliterated, and only the green rays are visible. Red lights then are recognized as green lights.

According to the theory just stated, a person is actually color blind only at the shortened ends of the spectrum, when a neutral band is present and in achromism. For example, for a person for whom a neutral band occupies the entire green area of the spectrum the color green does not exist. The adjacent colors have not encroached on this area, and it is, therefore, not changed to another color, as in some alterations in the spectrum. This applies to the shortened end or ends of the spectrum as well. Therefore, these areas are achromic and are seen as gray, and the colors normally found in these areas are likewise gray to the subject.

Comment.—Color vision that is normal in all respects is the desirable state. It is doubtful, however, if defective color vision, other than dichromism with and without a neutral band and color vision in which there is a shortened red end of the spectrum, is of paramount importance. Incidentally, dichromism, color vision in which there is a neutral band in the spectrum and that in which there is a short red end of the spectrum are the only types of defective color vision readily detected in routine tests. The Stilling and Ishihara plates are designed to detect, primarily, color blindness for red and green, a neutral band and a short red end of the spectrum. With the complete Holmgren yarn test, if that is properly conducted, the entire spectrum can be investigated, and this is the most efficient test employed. However, this test is time consuming, and its employment as a routine procedure in all examinations, in cases in which large numbers of persons are being investigated, is nearly prohibitive. The Jennings self-recording test is valuable but it lacks the flexibility of the test with the Holmgren skeins.

The approved method of conducting tests of color vision is, briefly, as follows: The examinee is tested with the Ishihara plates. If he reads all the figures correctly and promptly, except figures 5 and 2 in plates 10 and 11, traces a continuous line from x to x in plates 14 and 15 and fails to trace such a line in plate 16 he is reported as possessing normal color vision. If significant errors are made in reading the figures or in tracing the lines he is then tested with the Holmgren skeins. He is required to match greens, reds and rose under daylight illumination. The number of skeins of each color selected, the errors made, whether he is prompt or hesitant, whether or not selections are made by direct comparison and whether they are changed after such comparison are noted. If, for example, a brown is selected with greens, the brown selected is then used as the test color, and his selections are recorded. Finally, he is asked to select what he considers to be the three brightest colors in the lot. These selections are noted and a statement made as to whether or not the examiner is in accord with these selections.

The requirements of the armed forces are as follows:

If it is apparent that mistakes made by the examinee are due to confusion and not to carelessness or failure to understand instructions, he is disqualified. This standard applies to all classes of examinations.

The Department of Commerce has established the following qualifications:

Ishihara test official. A limited commercial or transport pilot is required to see the dominant colors. If he is deficient in the weaker hues of any or all colors he will not be disqualified. If an applicant should be color blind according to the Ishihara color charts, you should forward a classification of his color vision according to other tests, such as the Holmgren, Jennings, or Williams lantern. Although the test is given for the non-commercial grades, color blindness will not be considered as a disqualifying factor.

REACTION TIME

The reaction time of students of flying has been well investigated during recent years, particularly at the Army School of Aviation Medicine. The average reaction time of the satisfactory student was found to be eighteen hundredths of a second. A student whose reaction time was more than twenty hundredths of a second was considered as questionable flying material, although he was never eliminated as a flier on the basis of this factor alone.

Various types of machines for determining the reaction time have been devised for this work. Stimuli and physical responses to the stimuli have ranged from a single electric light, the response consisting of a single movement of one finger, to a complicated series of electric

lights, the response consisting of coordinated movements of both hands and feet. With some types of machines responses were recorded in hundredths of a second, while with other types group reactions were the basis on which the examinee was rated, i. e., a given number of responses required per minute.

In 1924-1925 measurements of the reaction time were made on two successive classes of students flying, about two hundred and fifty in all. Two series of tests were given. One series required a response consisting of a single movement of one finger, and the second series required a response consisting of a single movement of one finger of either the right or the left hand, depending on the color and position of the stimulus (electric light).

It was demonstrated that a large percentage of students, those with a reaction time longer than twenty-hundredths of a second, were either considered for elimination or were actually eliminated by the flying department because of inability to make proper progress in flying. It was discovered, however, that the record of the reaction time influenced the decision of the board to a considerable degree, thereby nullifying any definite conclusions that may have been drawn as to the value of this factor. Later investigations in this field were well controlled, and a quantity of valuable data were obtained.

Complicated responses are always influenced by experience, while in the simple responses experience plays a negligible part. It seems that, so far as the medical examiner is concerned, the basic or inherent reaction time is all that need be considered. It is the task of the medical examiner to turn over to the flying department students who are mentally and physically normal, while their learning time is a problem for the instructors in flying.

FLYING GOGGLES

For flying in a plane with an open cockpit goggles must be worn. Numerous types have been devised. All types restrict the field of binocular fixation to a marked degree, but if a 20 degree field is maintained in all directions of gaze a serious handicap is not incurred. Lenses are furnished the standard type goggle, in which presbyopic segments are inserted. These segments are so placed that they interfere in no way with distant vision. These have proved to be very satisfactory in reading the instrument board, reading maps while in flight and for similar purposes. Corrections for distant vision have been ground in goggle lenses, but this procedure has not proved as satisfactory as the presbyopic correction. A spectacle frame designed to be worn under the goggle has proved to be satisfactory in many instances.

Many of the modern types of airplanes are constructed with an enclosed cockpit, and the high speed attained with these ships makes

flying in an open cockpit impossible in any case. Goggles are unnecessary in an enclosed cockpit, and it is reasonable to assume that in the near future the flying goggle will cease to be an item of regular flying equipment.

GENERAL COMMENT

The ocular requirements set by regulations were adopted when flying was in its infancy. These requirements could not be based on experience relative to flying and were, therefore, more or less arbitrary. The requirements represent, however, the limits assumed by ophthalmologists to be those within which ocular efficiency can be maintained under varying conditions.

From a purely scientific standpoint it has never been demonstrated, in aviation, that these limits are justified in all instances. For example, an average error of depth perception of 25 mm. is considered as the limit of safety and by constant use has become a psychologic fact. This limit is, however, based on laboratory tests and not on actual experience in the air. A person with a persistent average error greater than 25 mm. has never been permitted to demonstrate his ability to learn to land and maneuver a plane under all conditions. The same criticism is applicable to many other ocular restrictions. The lack of conclusive proof does not, however, warrant relaxation of the ocular requirements, because the basis on which they are founded are sound. It may be said that the more efficient the ocular equipment of a person the more reliable he will be as a flier and the more enduring will be his flying career.

Correspondence

TREATMENT OF NEUROPARALYTIC KERATITIS BY CLOSURE OF THE LACRIMAL CANALICULI

To the Editor:—In reply to Dr. F. H. Verhoeff's criticism, in the December 1937 issue of the ARCHIVES (page 1027), of our paper entitled "Prevention and Treatment of Keratitis Neuroparalytica by Closure of the Lacrimal Canaliculi: Report of a Case" (ARCH. OPHTH. **18:** 325 [Sept.] 1937), we would say that it appears to us that Dr. Verhoeff has overlooked the fact that our presentation was only a case report; that one case report was never intended to exhaust any subject, and that we still think our comment, "It is comparable to the results described by Beetham after he had closed the ducts in patients with filamentary keratitis," and our correct reference to Beetham's paper could only mean that we gave him full credit for the procedure. While Beetham closed the ducts in the treatment of a series of patients with filamentary keratitis, we did it in but one patient suffering from neuroparalytic keratitis, in whom a dry eye followed section of the posterior root of the fifth cranial nerve by the suboccipital craniotomy approach of Dandy. This was the first time, as far as we know, that the canaliculi had been blocked in a case of neuroparalytic keratitis.

We have been interested for more than ten years in the control of the secretion of tears by the nervous system. The plan we have followed while studying the subject was molded after that described by Parsons (*Roy. London Ophth. Hosp. Rep.* **15:** 81 [May] 1902). It consists in the study of tearing in patients with a variety of neurologic lesions, and from our work we have been able to reach no constructive conclusions. We have found, for example, that in patients with tumor of the eighth nerve in whom it was necessary to sacrifice both the seventh and the eighth cranial nerve in order to extirpate the tumor, the secretion of tears varied greatly. We have even found the amount of tears after certain types of stimulation to be twice as great on the side from which the tumor was removed as on the normal side. This is but one of the points that has made us question the part that the greater superficial petrosal nerve plays as a secretory nerve to the lacrimal gland. In the case reported the operation was carried out through the posterior fossa, as advocated by Dandy, and not through the commonly used approach, the temporal fossa, as advocated by Frazier. The patient showed no evidence of damage to the facial nerve after operation, and it is impossible to damage the greater superficial petrosal nerve itself in this approach.

The method we have used for measuring tearing was suggested by Dr. Theodore Erickson, who had used Poth's method of measuring salivary secretion while studying a case of neuralgia of the glossopharyngeal nerve after section of the ninth nerve (Paroxysmal Neuralgia of the Tympanic Branch of the Glossopharyngeal Nerve, *Arch. Neurol. & Psychiat.* **35:** 1070 [May] 1936). The method we described was used in the case reported, and it is clearly stated in the communication

that "measurements proved that secretion of tears was present on the involved side, but it was only one sixth of the amount in the left eye." In this patient lacrimal secretion was measured repeatedly by the method we outlined, both before and after closure of the canaliculi and after the use of various stimuli. Had we been unable to prove that lacrimal secretion was present, there would have been no point in closing the ducts to dam back what did not exist.

Neuroparalytic keratitis developed in this case six months after section of the posterior root. The lids were sutured and left closed for seven months. The canaliculi were blocked thirteen months after the operation, when return to normal secretion seemed unlikely. Dr. Verhoeff's suggestion that the canaliculi might better be tied off instead of permanently closed when tear secretion might possibly be restored seems reasonable to us, particularly because of our knowledge of Dr. Buller's early employment of this procedure in cases of infection of the tear sac (*Montreal M. J.* **31:** 186, 1902).

In conclusion, we should like to reiterate our opinion that the greater superficial petrosal nerve and the seventh nerve are not so important as secretory nerves to the lacrimal glands as the literature and textbooks indicate. The case reported by us and the cases of tumor of the eighth nerve in which the seventh nerve was sacrificed, cited in the correspondence, are but two of other observations supporting this opinion.

J. A. MacMillan, M.D.,
William V. Cone, M.D.,
Montreal, Canada.

News and Notes

UNIVERSITY NOTES

Postgraduate Course in Ophthalmology, Harvard University Medical School.—During May the department of ophthalmology of Harvard University Medical School is conducting an all day, four week graduate course in recent advances in ophthalmology. This course is given at the Massachusetts Eye and Ear Infirmary, the entire staff participating, and is open only to men and women qualified in ophthalmology (and not to beginners). It correlates advances in fundamental science with clinical ophthalmology and affords an opportunity for study of pathologic sections, neuro-ophthalmology, preoperative and postoperative treatment, with visits to the wards, ocular complications in general diseases and physiologic optics as applied to refraction.

Registration can be made through the Assistant Dean, Courses for Graduates, Harvard University Medical School.

Course in Study of Ocular Muscles, the Massachusetts Eye and Ear Infirmary.—If sufficient applications are received by April 1, an all day, two week course in the study of the ocular muscles will be given at the Massachusetts Eye and Ear Infirmary by Dr. A. Bielschowsky and Dr. V. G. Casten from April 18 to 30 inclusive.

Postgraduate Course, Oregon Academy of Ophthalmology and Oto-Laryngology.—The third annual postgraduate course in ophthalmology and otolaryngology under the auspices of the Oregon Academy of Ophthalmology and Oto-Laryngology and the University of Oregon Medical School will be given in Portland, April 3 to 9, 1938.

The course is primarily intended for those in special practice, but the program committee has announced that subjects of practical interest to men in active practice will be given the first consideration.

The guest teachers this year are Dr. A. C. Furstenberg in otolaryngology and Dr. Sanford Gifford in ophthalmology. The mornings will be given to lectures and demonstrations by the guest speakers. The afternoon sessions will be held at the outpatient clinic of the medical school, and in the evenings Dr. Olof Larsell, professor of anatomy, will demonstrate the surgical anatomy of the head and neck. Copies of the program may be secured by writing to Dr. Paul Bailey, 929 Medical-Dental Building, Portland, Ore.

Obituaries

DAVID HARROWER, M.D.

1857–1937

On Aug. 8, 1937, David Harrower died at his home in Worcester, Mass. He was born in Watervliet, N. Y., on June 13, 1857, of Scottish parents, descendants of a Huguenot family of Picardy, France. Soon after his birth, the family moved to Peace Dale, R. I.

Educated in Providence, R. I., principally at the Moses Brown School and Mowry and Goff's English and Classical School, David Harrower entered the Harvard University Medical School, graduating in 1884. The next three years he spent abroad, studying ophthalmology and otolaryngology in Edinburgh, London, Vienna, Berlin and Paris. While in London, he served six months as resident surgeon at the Royal London Ophthalmic Hospital (Moorfields) and attended the Central London Ear, Nose and Throat Hospital.

Returning to the United States, he opened an office in Worcester, Mass., being the first well trained ophthalmologist to settle in the city. One of the first, if not the first, extraction for cataract in central Massachusetts was performed by him.

For fifty-two years he served on the staffs of the Worcester City Hospital and the Memorial Hospital, the last twenty years as a consultant. He was a member of the staff of the St. Vincent Hospital for forty-five years, and for many years was a consultant to the Fairlawn Hospital, the Baldwinsville (Mass.) Hospital Cottages for Children, the Milford (Mass.) Hospital, the Holden (Mass.) District Hospital and the Peterborough (N. H.) Hospital.

He was a member of the Massachusetts Medical Society for fifty-three years; the last thirty-two years he served as a counselor and the last twenty-four years as a member of the Nominating Committee. In 1889 he became a member of the American Ophthalmological Society; later he served on the Council, and in 1926 he was president of the society. He also held membership in the American Otological Society and the New England Ophthalmological Society and was a charter member of the American College of Surgeons.

His private practice was very large, his patients coming from all parts of central Massachusetts and the neighboring states of New Hampshire, Rhode Island and Connecticut. He never hesitated to see any one, and his charitable work was extensive.

He was always an inspiration to younger men, ever ready to lend a helping hand, without the jealous superiority frequently observed in older

practitioners. The high ethics of the old school were always in evidence. He had no time for arrogance, ignorance or sham. An inherent joviality and kindness combined with a large experience and common sense made him a delightful and most satisfactory consultant.

His interest in scientific ophthalmology never waned. Particularly interested in glaucoma, he was one of the first ophthalmologists in the United States to employ Borthen's technic for the treatment of glaucoma by iridotasis and the first to contribute his observations to ophthalmic literature in the United States.

Popularity in his community was evidenced by a host of loyal friends, and his interest in local affairs was always keen. He never hesitated to praise when praise was due. He was a member of the Worcester Club, the Tatnuck Country Club and the Harvard Club of Worcester and of Boston as well as of several other local clubs and societies.

Surviving him are his widow, the former Mary D. Struthers, to whom he was married in Edinburgh, Scotland, on July 27, 1886, three sons, Norman (of Fitchburg, Mass.), Gordon (of New York) and Francis (of Cornwall, Ontario, Canada), and four grandchildren.

WILLIAM F. HOLZER.

JAMES HENRY ANDREW, M.D.

1874-1937

Dr. James Henry Andrew was born at Cambridge, N. Y., on July 29, 1874, and died at the Brooklyn Hospital on Nov. 26, 1937, after a severe and painful illness. He was buried in Woodland Cemetery, at Cambridge, N. Y. Dr. Andrew's ancestors came from Scotland about 1750 and settled in eastern Pennsylvania.

His father, a Presbyterian minister, who occupied charges in different parts of the country, finally came to Brooklyn, so that Dr. Andrew, though born in Cambridge, lived most of his life in that city. While different members of the Andrew family have occupied many prominent positions in the country's history, Dr. Andrew's father remarked, "If we have not been a princely race, we have been a godly one, which," he added, "is much better." The family was of the stock which has made this country great.

Dr. Andrew graduated from the Polytechnic Collegiate Institute in Brooklyn and later received his medical degree from Bellevue Hospital Medical College, New York, in 1896. After practicing general medicine for nine years, he decided in 1905 to devote himself to the practice of ophthalmology and became associated with Dr. Marple's clinic at the New York Eye and Ear Infirmary. After four years' connection with that institution, he transferred his hospital association to the Brooklyn Eye and Ear Hospital. There he was appointed assistant surgeon and associate surgeon in Dr. Jameson's clinic, where he served until he was appointed to a full surgeonship in 1925, a position held by him with distinction until the day of his death.

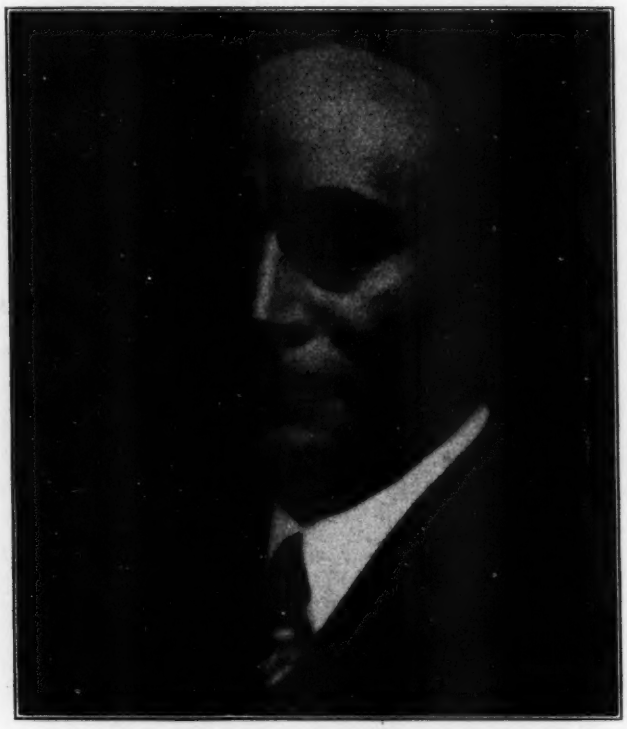
Dr. Andrew was a member of the American Medical Association, the American College of Surgeons, the American Ophthalmological Society, the American Academy of Ophthalmology and Otolaryngology, the New York Ophthalmological Society, the Medical Society of the County of Kings and the Brooklyn Ophthalmological Society, of which he was a past president. In addition to the surgeonship at the Brooklyn Eye and Ear Hospital, he was ophthalmologist to St. John's Hospital, the Bushwick Hospital, the Beth Moses Hospital and the Samaritan Hospital.

Dr. Andrew was a constant attendant at the meetings of his medical societies. He was a good speaker and discussed the papers soundly and with clarity.

While he was an excellent clinician, his great forte was in the operating room. Few ophthalmic surgeons were more dextrous, and when

he operated he would always have a goodly audience. He had a singularly even and lovable disposition which endeared him to his patients and associates. He was tall and though dignified was easily approachable and invariably courteous to those who assisted him in his clinic and who labored with him in the wards.

The word "Andrew" means manly or manlike, and Dr. Andrew fitted the characterization. He was passionately fond of the outdoors and was a keen hunter and angler. Few sportsmen cast a line farther,



JAMES HENRY ANDREW, M.D.
1874-1937
(Photograph reproduced by permission of Pach Brothers, New York.)

to land more gently and unerringly at the desired spot. Supremely happy were the days he spent with his friends in these pursuits.

Dr. Andrew possessed a heaven-born gift of humor, and his delight was to tell Scotch stories, which he did well. If he could relate these stories and fit them to a Scotch friend, his face would beam with mischievous glee.

Dr. Andrew was a good Christian and a fond and devoted husband and father. His memory remains green on the tablet of our hearts, for "he banked his treasure there," and there it will remain.

P. CHALMERS JAMESON, M.D.

Abstracts from Current Literature

EDITED BY DR. WILLIAM ZENTMAYER

Biochemistry

VITAMIN C IN THE OCULAR TISSUES AND LIQUIDS: ITS RELATION TO THE BIOLOGY OF THE LENS. G. BIETTI, Boll. d'ocul. **14:** 3 (Jan.) 1935.

Bietti repeated and enlarged on the work of Müller, who showed the presence of a reducing agent in the aqueous, which was much diminished when the lens was removed, and which he considered was vitamin C (cevitamic acid). Using Tillmans' reagent as indicator, he estimated the amount in aqueous from which the protein had been removed by trichloracetic acid. With this method cevitamic acid was found to be present in the aqueous of the animals tested and in that of man. In herbivorous animals (cattle, sheep, rabbits) and in man ten to fifteen times the amount present in the dog and cat was found. It was reduced 50 to 75 per cent in the second aqueous, which was withdrawn after twenty minutes. In rabbits from which one lens had been removed the amount in the aphakic eye was only one fifth of that in the normal eye. These findings confirmed Müller's opinion that the amount of cevitamic acid in the aqueous depends on the presence of the lens. Bietti examined the lenses of animals and found approximately the same amounts per gram of fresh lens as per cubic centimeter of aqueous. The amounts in the cortex and nucleus of young and old cattle were estimated. In young animals the amount in the cortex was only slightly less than that in the nucleus, while in old animals there was a considerable reduction in the amount present in the nucleus. The amount in the anterior portion of the uvea, vitreous and retina of the beef was from one half to one third of that in the aqueous and lens.

Since Tillmans' reagent is not specific for cevitamic acid, dietary experiments were carried out on guinea-pigs in which a diet free from vitamin C was supplemented by fresh beef aqueous or lens substance. A definite protective effect of both aqueous and lens substance could be shown in these animals, which outlived the controls considerably. The effect was less, however, than that of orange juice containing approximately the same amount of cevitamic acid as calculated by Tillmans' indicator.

Bietti next examined the aqueous and lens of animals with naphthalinic cataract and of patients with various types of cataract. In the naphthalinized animals a marked reduction in cevitamic acid was found which was in general proportionate to the degree of opacity. Of the ten patients a marked reduction of cevitamic acid in the aqueous was shown in all but one, a child with zonular cataract. The vitamin was most reduced in two patients with cataracta nigra and nuclear cataract and in aphakic eyes, less so in intumescent senile and in traumatic cataract. Reduction of the amount in lenses removed at operation was equally marked, especially in cases of sclerotic and black cataract.

The amount in eyes of rabbits submitted to roentgen rays was also reduced. Hence the presence of cevitamic acid seems to depend not only on the presence of the lens but on its vitality. Fischer believed that cevitamic acid ($C_6H_8O_6$) is formed in the lens by dehydrogenation of a molecule of dextrose in the presence of a hydrogen acceptor (systine). Bietti found that by administering large amounts of orange juice to rabbits the amount of cevitamic acid in the blood was almost doubled and likewise that in the aqueous, while that in the lens showed only a slight or no increase. In the dog, however, the amount in the aqueous remained unchanged, and that in the blood showed only a slight and very fleeting increase. Animals with experimental infection of one cornea showed a marked reduction in the cevitamic acid of the aqueous, which may indicate an interference with the pemeability of the ciliary epithelium to this substance. Bietti believes that dehydrocevitamic acid, which is present in the blood stream in amounts equal to that in the aphakic eye, passes through the ciliary processes into the aqueous and that here in the presence of a normal lens it accepts hydrogen to form reduced cevitamic acid.

In discussing the possible relations of vitamin C deficiency to cataract, Bietti favors the view that deficiency of cevitamic acid in the aqueous is the result rather than the cause of cataractous changes in the lens. He was not able to prevent or influence naphthalinic cataract by administering vitamin C.

S. R. GIFFORD.

Congenital Anomalies

UNILATERAL CONGENITAL ANOPHTHALMOS WITH ORBITOPALPEBRAL CYST. M. ROSENBAUM, Am. J. Ophth. **19**: 1101 (Dec.) 1936.

Rosenbaum reports a case of congenital anophthalmos of the left eye associated with an orbitopalpebral cyst in which the cyst was removed and examined pathologically. Roentgen examination revealed rudimentary frontal sinuses; the left orbit was smaller than the right, and there were a cataract and irregularity of the optic foramen on the left. The right eye was normal. The author discusses the origin of these defects and states the following conclusion:

"Every idiogenetic malformation has its ontogenetic characteristics, which are inherent in its gametes. It is important to note that such embryonal end result is not pathological, but only differentiated, as a result of arrest of development."

W. S. REESE.

A PREVIOUSLY UNDESCRIBED MALFORMATION OF THE PALPEBRAL FISSURE, CONJUNCTIVA AND CORNEA. G. BIETTI, Boll. d'ocul. **13**: 1537 (Dec.) 1934.

A baby girl 4 days old was seen who was normal except for the ocular deformities to be described: The eyelids were present, though the upper lids were smaller than normal. They were held widely apart by a fold of skin, with which the upper lid borders were fused directly, while below, under the fold of skin, shallow culdesacs were present. The folds of skin covered the globes except for a small part of each

cornea which was exposed. The corneas were small and xerotic, and the interior of the globes could not be seen through them. Bietti supposes that the adhesion between the lid borders which usually occurs was interfered with in some way, which prevented the normal development of conjunctiva and cornea, the former being largely replaced by skin. Possibly an amniotic band may have been a factor. The relations of this condition with cryptophthalmos and congenital symblepharon are discussed.

S. R. GIFFORD.

Cornea and Sclera

CORNEAL CORPUSCLES IN THE REACTION OF HYPERSENSITIVENESS. H. D. LAMB, Am. J. Ophth. **18:** 644 (July) 1935.

Lamb briefly reviews the work of different observers on the action of corneal corpuscles in keratitis. He enumerates his observations, comparing them with those of von Szily, who made the only previous report on the anatomic changes in the cornea from hypersensitiveness.

W. S. REESE.

BILATERAL MESIAL SUPERFICIAL DEFICIENCY OF THE SCLERA. B. GRAVES, Brit. J. Ophth. **21:** 534 (Oct.) 1937.

Graves has observed a number of cases of a condition which sometimes, at the first casual glance, suggests that tenotomy of the internal rectus muscle has been performed in the past, owing to a small, sharply defined area where the sclera looks thinned, appearing less white than the surrounding scleral tissue.

With the biomicroscope "the visible definition of the bounding edge varies relatively with the conditions of illumination; and what is, under constant conditions of illumination, interpretable as the absolute or structural definition of the edge may vary in different cases and in different parts of the same case."

W. ZENTMAYER.

THE TECHNIC OF CORNEAL TRANSPLANTATION: THE HERMETIC TREPHINE OF FILATOV AND MARTZINKOVSKIY. V. P. FILATOV, Sovet. vestnik oftal. **8:** 159, 1936.

This modified trephine (FM-2) prevents injury of the lens without use of Filatov's prophylactic spatula. It is most useful in the treatment of leukoma when the anterior chamber is present. The crown of the trephine is conical so that when it incises the leukoma it closes the hole of the incision hermetically. Besides this there is a hermetic membrane in the canal of the crown 5 or 6 mm. from the cutting edge. When the leukoma is incised the aqueous and incised disk escape to the space provided for it by the membrane instead of to the canal; thus the anterior chamber remains present, and the knife will not touch the lens. The new model has been successfully used in many corneal transplantations. If vitreous appears, one should apply Filatov's retrograde obturator and his spatula. Several drawings illustrate the article.

O. SITCHEVSKA.

Experimental Pathology

THE MECHANISM OF EXPERIMENTAL EXOPHTHALMOS. C. F. CODE and H. E. ESSEX, Am. J. Ophth. **18:** 1123 (Dec.) 1935.

Code and Essex give the following summary:

"Careful dissections of the orbital contents of dogs have been carried out. The attachments and histologic structure of the conical fascial sheath which encloses the orbital contents (membrana orbitalis) have been described.

"Electrical stimulation of the central end of the cut vagosympathetic trunk causes circular contraction of the cone-shaped sheath, with forward movement of the eye. Smooth-muscle fibers are present in the cone-shaped sheath.

"The action and independent contraction of the sheath have been established by the following observations: When a longitudinal incision is made through the superior surface of the cone, vagosympathetic stimulation causes separation of the edges of the incision, with very slight forward movement of the eye. A raised flap of the sheath shortens on vagosympathetic stimulation. Isolated strips of the cone perfused in oxygenated Ringer's solution contract on the addition of ephedrine to the perfusion fluid. When the eye is enucleated and replaced by a rubber balloon, vagosympathetic stimulation causes visible contraction of the cone and a rise of pressure in the balloon.

"The action of the smooth-muscle fibers present in the cone-shaped sheath is such that by their contraction the eye is squeezed out of the orbit.

"The surgical removal of a wedge-shaped strip of the conical sheath (membrana orbitalis) produces chronic enophthalmos."

W. S. REESE.

VISUAL FUNCTION AND THE GLYCIDES IN THE OCCIPITAL LOBE OF THE RAT. F. SCULLICA, Ann. di ottal. e clin. ocul. **64:** 50 (Jan.) 1936.

Previous work is reviewed showing that following intense muscular activity a reduction in the glycides of the cerebral motor areas is present. Scullica attempted to determine whether the same relation obtains between sensory function and the glycides of sensory areas.

One group of adult rats were blinded by cauterization and killed after five days, and the content of the occipital lobes in glycides was compared with that of normal animals of the same age.

A second group of rats 25 days old were similarly blinded but were allowed to live four months before being put to death and examined in the same way.

In the first group the occipital lobes of the blinded animals showed an increase in glycides over those of the controls amounting to from 29 to 34 per cent. In the group allowed to live four months the opposite results were obtained, a reduction of from 35 to 36 per cent being found in the blinded animals.

Scullica believes that the results in the first group showed a storing of glycides in the animals recently deprived of the use of vision, while those in the second group showed a loss of these substances due to prolonged lack of the visual function.

S. R. GIFFORD.

General

THE INFLUENCE OF THE VITAMIN-D—CALCIUM-PHOSPHORUS COMPLEX IN THE PRODUCTION OF OCULAR PATHOLOGY. S. N. BLACKBERG and A. A. KNAPP, Am. J. Ophth. **20:** 405 (April) 1937.

This article does not lend itself to abstracting. The authors think that deficient vitamin D—calcium-phosphorus complex may cause weakening of the cornea or sclera and suggest that it may be causative in myopia. Studies are now being made of patients with myopia and primary corneal ectasia, and encouraging results have been obtained from medication designed to rectify the deficient diet.

W. S. REESE.

THE VISUAL ORGAN IN PROLONGED (FIFTY DAYS) STARVATION. M. Y. FRADKIN and L. D. SHAVIN, Sovet. vestnik oftal. **7:** 874, 1935.

The subject, mentally alert, married, aged 38, conductor of an orchestra, submitted himself to the experiment because he believed that prolonged hunger causes complete regeneration of the whole organism and because he had seen mild cystitis clear up in one of his previous experiments with hunger. The general physical condition with the exception of the cystitis was good. The eyes were normal. The intraocular tension (Schiötz) was 22 mm. The blood pressure, taken with Bailliart's ophthalmodynamometer, was 70 systolic and 40 diastolic. The dark adaptation (Birch-Hirschfeld adaptometer) was within normal limits.

He refused to take food or water the first four days; thereafter he drank 600 cc. of water daily. Up to the forty-seventh day he worked six hours daily at a book on starvation. He lost 16.1 Kg., or 26.52 per cent of his body weight. There was gradual decrease of the systolic and increase of the diastolic blood pressure. The pulse rate decreased to 50 beats per minute and the temperature rose to 35.7 C. (99.9 F.).

The eyes showed the following changes: The retina was pale. The intraocular tension was lowered to 10 mm., probably as a result of loss of water from the tissues and from the vitreous. The arterial pressure was 55 systolic and 40 diastolic. The dark adaptation of the rods was markedly lowered while that of the cones remained unchanged. All the changes in the eyes were similar to those produced by avitaminosis, particularly by insufficiency of vitamin A.

O. SITCHEVSKA.

Hygiene; Sociology, Education and History

REQUIREMENTS OF GOOD DESK LIGHTING. C. E. FERREE and G. RAND, Am. J. Ophth. **20:** 286 (March) 1937.

Ferree and Rand give the following summary:

"In this paper the requirements of a good desk lamp are outlined and discussed, and one model constructed as a sample is described.

"A satisfactory desk lamp should embody the following features:

"(1) Adequate intensity of light should be provided, also a means for varying intensity to suit individual needs and different types of work without changing the color and composition of the light or the size, shape, or location of the illuminated area.

"(2) The unit itself should be glareless when used with lamps of either low or high wattage.

"(3) It should be placed at a sufficient height to give a wide field of illumination. This spread of light can be increased by certain provisions in the construction of the unit, such as are described.

"(4) The light should be well diffused and evenly distributed on the plane of work and there should be a well-balanced placement of light and brightness in the field of view. For securing this latter condition, an upward component of light is an important factor in addition to the complete elimination of glare from the lighting unit itself.

"(5) Glare on the work should be reduced to a minimum. Diffusion of light and height of unit above the plane of work are important factors in securing this result. The most effective means for eliminating glare on the work, however, is a suitable provision for varying the placement of light.

"(6) The light should be made to approximate daylight in color and composition. For many eyes, particularly in certain pathologic conditions, this is almost imperative."

W. S. REESE.

Instruments

A CUPOLA PERIMETER: MODIFICATION OF THE CLASSIC PERIMETER. A. BUJADOUX, Ann. d'ocul. **173:** 888 (Nov.) 1936.

A modification of the pistol-like perimeter of Magitot is described in which the arc of the perimeter is replaced by a lighted cupola fixed in place, which can be easily maneuvered.

The instrument and its operation are described in detail. There are three illustrations.

S. H. MCKEE.

NEW KNIFE FOR MELIORATION. A. P. MARTSINKOVSKIY, Vestnik oftal. **10:** 641, 1937.

Martsinkovskiy constructed, on Filatov's suggestion, a special knife, FM-2, for the shaving off of the anterior layers of the cornea. It has double sharp edges, so that a strip of cornea can be cut off without the knife being turned. Six drawings illustrate the knife and the method of its use.

O. SITCHEVSKA.

Lens

THE HISTOLOGY OF THE ROENTGEN CATARACT: REPORT OF A CASE. J. GRZEDZIELSKI, Klin. Monatsbl. f. Augenh. **95:** 360 (Sept.) 1935.

A man aged 31 received three roentgen irradiations for trichophytia profunda barbae at intervals of one week in February 1930. During exposures of the chin and cheeks the eyes remained unprotected. A resultant so-called ophthalmia electrica disappeared within two weeks. The doses of radiation and the details of their application were not known to the author. Vision decreased in August 1933. Intracapsular extraction of the lenses was done. The results of examination with the slit lamp and the histologic observations are reported.

The slit lamp showed numerous subcapsular opacities arranged around the anterior pole of the lens and radially distributed toward the periphery. Many vacuoles of varying size were present behind the anterior capsule. The nucleus was clear. Subcapsular opacities in the posterior cortex formed a ring-shaped, striped and horizontal-oval cloudiness. The center of this ring contained a few isolated glistening dots; it was so clear as to allow a view of the vitreous. The radial striations extending toward the periphery showed stripes resembling those of the annular opacity. Inspection with the narrow beam showed the inner opacity of the ring well defined by an anteriorly concave line which disappeared toward the periphery in the layer of the subcapsular opacities. Thus a meniscus was formed.

The histologic examination revealed proliferation and degeneration of all anterior and posterior subcapsular layers. The changed areas were well defined from the remaining cortex. The fibers of the lens were edematous and some of them were disintegrated, forming detritus. The posterior subcapsular zone presented the central disk-shaped area which had been observed with the slit lamp. This area was composed of spheroid vacuoles with a faintly staining content. The fibers of the cortex and the nuclei were well preserved. The microscopic changes consisted chiefly in proliferation of the epithelium of the lens.

Such a roentgen cataract originates by proliferation of the cells of the epithelium below the posterior capsule of the lens and by their degeneration at the posterior pole of the lens

K. L. Stoll.

Intracapsular Extraction of Cataract in Country Practice. H. Elschnig, Klin. Monatsbl. f. Augenh. **98:** 191 (Feb.) 1937.

Elschnig describes in detail the preoperative care of the patient and his own method of operating for intracapsular extraction of cataract. Venesection, with removal of from 100 to 250 cc. of blood, is done one-half hour prior to the operation in cases of general hypertension. The lens is extracted in tumbling fashion by grasping its lower third with the forceps. Two sutures, arranged before the operation, are tied directly after delivery and one or two conjunctival sutures are applied afterward. Sterile air is injected into the anterior chamber with a hypodermic syringe and a blunt tear sac cannula. The air is well tolerated, even if the bubble of air is visible for from five to eight days. Reposition of the iris is not required, and vitreous prolapsed or protruding into the anterior chamber will be pushed back by the air. Deformation of the pupil by atrophy of the iris after prolapse of vitreous never occurred with this method.

K. L. Stoll.

Neurology

Unilateral Cerebral Dominance as Related to Mind Blindness: Minimal Lesion Capable of Causing Visual Agnosia for Objects. J. M. Nielsen, Arch. Neurol. & Psychiat. **38:** 108 (July) 1937.

The problem under consideration in this article is whether or not there is cerebral dominance, such as exists for speech and hearing, in

the elaboration of visual perception. Nielsen reviews former statements of opinion as to whether visual agnosia for objects (mind blindness) can be due to a unilateral lesion or must be bilateral.

In selecting cases for providing an answer Nielsen used the following critical rules:

"1. The record of the case as published not only must state that visual agnosia for objects was present but must offer evidence for scrutiny and independent diagnosis.

"2. Only one occipital lobe must have been affected. It is clear that if in any case a unilateral lesion produced visual agnosia, there can be no point in citing cases of bilateral lesion of the occipital lobe.

"3. The lack of recognition of objects must not have been due to general cerebral involvement or enfeeblement.

"4. The agnosia must have been more than transient. If the patient recovered before death or if diaschisis seemed to have been the cause of the syndrome, the case was not included.

"5. The lesion must have been verified."

He abstracts thirteen cases from the literature satisfying these criteria as genuine cases of "mind blindness." On the basis of facts in certain of these cases and in two additional cases of his own he emphasizes how natural handedness does not necessarily correspond with opposite brainedness and that one cannot determine which is the major occipital lobe by either handedness or brainedness, owing to the inconsistencies found. He then discusses the exact localization of the lesions in all the cases and presents the following conclusions, based on careful analysis of the material at hand:

"1. One occipital lobe is dominant over the other for recognition of objects.

"2. The dominant lobe is usually the left, but may be the right, even in right-handed persons.

"3. Within the occipital lobe the cortex of the second and third convolutions represents an area which is essential for the recognition of objects. It is not correct to say that here lie memory pictures, for a large part of the brain is utilized in constructing them, but visual memory pictures cannot be evoked without the function of this area.

"4. Impulses reach this area via the transverse occipital fasciculi of Sachs and Vialet from the same side and via the splenium of the corpus callosum from the opposite side.

"5. The so-called negative cases cannot be considered as such merely because the left occipital lobe was destroyed.

"6. Cases of lesions in both occipital lobes do not necessarily disprove the concept presented here. In order to disprove it, the specific fiber tracts or cortical area of the major occipital lobe must have been destroyed without producing visual agnosia for objects."

A note is appended calling attention to an article describing a case in which the splenium of the corpus callosum was severed for removal

of a tumor from the third ventricle, and, as the author's concept would predict, the patient subsequently had visual agnosia for objects in the left field of vision.

R. IRVINE.

Ocular Muscles

THE ROLE OF HETEROPHORIA IN BINOCULAR DISHARMONY, WITH SPECIAL REFERENCE TO AIR PILOTAGE. P. C. LIVINGSTON, Brit. M. J. 2: 409 (Aug. 28) 1937.

Livingston classifies heterophoria as inherent and acquired. In his language the inherent type is due to dominant macular reception either without rivalry (in which case symptoms do not arise in later life) or with rivalry (in which case the disorder is a potential source of trouble).

The acquired type may be a primary condition, induced by the circumstances of everyday life, or may be superimposed on the inherent type. The person who has a primarily acquired heterophoria complains of ocular discomfort early in the process because of good binocular vision. When an acquired heterophoria is superimposed on the inherent type the symptoms are proportionate to the binocular vision. In many cases heterophoria is symptomless, owing to a strong inherent tendency. Heterophoria can produce not only intense headaches but also a distinctly pathologic state of mind and may cause referred symptoms in other parts of the body.

Hyperphoria produces the most suffering, because binocular vision is quickly strained above the horizontal plane and subconscious control rapidly gives place to central conscious effort. Exophoria with a weak converging power, ocular rivalry, and cyclophoria are also likely to produce symptoms.

In flying, it is not invariable that the pilot with exophoria stalls his engine and the pilot with esophoria comes down heavily on his wheels. Usually a mixing of the high and low approaches occurs, due to overcorrection or undercorrection at succeeding attempts. Every discovered phoria is not the root cause of flying trouble. Fatigue, the onset of illness, a growing dislike for flying, and neurasthenia must be eliminated. Also, heterophoria may result from prolonged concentrated flying, asthenia, malaria, or an injury to the head.

A symptomless heterophoria is best left untreated. In symptom-producing conditions a complete survey of the patient is advisable. The stereoscope and amblyoscope are of value in treatment. Prisms are a temporary aid in heterophoria following cerebral concussion. After a few months they can be reduced in strength, and after six months training can usually be instituted. For a residual deviation, prisms may be prescribed to correct from one half to two thirds of the total deviation.

Prisms are also of value for relieving an inherent or acquired symptom-producing hyperphoria. Operation and suitable orthoptic training may help these patients. The prism power should be divided suitably (but not necessarily equally) between the two eyes.

W. F. DUGGAN.

Pharmacology

MYDRIATIC ACTION OF CERTAIN SYMPTOMIMETIC SUBSTANCES: EPINEPHRINE, EPHEDRINE, PARA-METHYL AMINO-ETHANOL PHENOL TARTRATE AND ORDENIN. A. CASTELLI, Arch. di ottal. **42**: 95 (March-April) 1935.

These four drugs of similar chemical structure were studied with regard to their effect on the pupil, the muscles of accommodation and the intra-ocular tension. As test animals, Castelli chose the dove, which has only striped muscle in the iris without sympathetic innervation, and the rabbit, which has smooth muscle with mixed sympathetic and parasympathetic innervation.

None of the drugs had any effect on the dove's iris whether given by instillation, subconjunctival injection or injection into the anterior chamber. In the rabbit all the drugs, when given by instillation, produced slight mydriasis after one hour. The solutions employed were 1 : 1,000 epinephrine hydrochloride, 1, 5 and 10 per cent ephedrine, 1 and 2 per cent para-methyl amino-ethanol phenol tartrate and 1 and 5 per cent ordenin. When injected subconjunctivally, all the drugs except ordenin produced mydriasis after five minutes, which became complete in ten minutes and lasted six hours. Ordenin produced no effect. Injection into the anterior chamber produced the same results, the mydriasis being no more marked than after subconjunctival injection. The same effects were produced on enucleated eyes of frogs and in rabbits which had undergone complete sympathectomy thirty days before, the mydriasis being more complete than on the side without sympathectomy. Hence connection with the sympathetic chain is not necessary for the reaction, the drug acting on the neuromuscular endings or on the muscle itself. Clinical experiments showed that pupils only partially dilated with atropine could be further dilated by subconjunctival injection of epinephrine hydrochloride, so that a stimulation of the dilator must be involved, which the author believes is accompanied by relaxation of the sphincter.

A group of patients was treated with all four drugs at various times, employing 1 : 1,000 solution of epinephrine hydrochloride, 5 per cent ephedrine, 2 per cent para-methyl amino-ethanol phenol tartrate and 5 per cent ordenin. Epinephrine hydrochloride by instillation produced no effect in 147 of 202 persons, and only in 4 of the group was marked mydriasis produced. There was usually, however, a fall in intra-ocular tension of from 3 to 4 mm.; this was greatest one hour after instillation and was proportionate to the ischemia produced but not to the mydriasis. Little or no effect was produced on accommodation. Five per cent ephedrine produced mydriasis in all but 5 of 179 persons; it was slight in 99, moderate in 65 and marked in 10. It was usually maximal after forty-five minutes. The intra-ocular tension was elevated in most persons, usually more than 4 mm. There was no effect on accommodation; there was no sensation of burning, but there was moderate congestion. Two per cent para-methyl amino-ethanol phenol tartrate produced only slight mydriasis in 20 of 94 persons and a slight decrease of tension of about 2.5 mm. Ordenin produced no effect by instillation.

Castelli concludes that 5 per cent ephedrine is the most effective of the sympathomimetic drugs for clinical use in producing mydriasis

by instillation, while 1:1,000 epinephrine hydrochloride, when used subconjunctivally, is very effective. In using ephedrine, 10 drops of 1:1,000 epinephrine hydrochloride is added to 20 cc. of the solution to counteract the congestion produced by ephedrine alone.

S. R. GIFFORD.

Physiology

LATENCY OF CORTICAL AND RETINAL ACTION POTENTIALS INDUCED BY ILLUMINATION OF THE EYE. GING-HSI WANG, Arch. Neurol. & Psychiat. **37:** 772 (April) 1937.

Adding to his previous work on the effect of intensity of light on the latencey of action potentials in the visual cortex of the rabbit in response to photic stimulation of the eye, the author now shows that the latency also varies with the rate of increase in intensity of the light used to excite the retina. A cortical potential wave produced by a sudden exposure of the retina to an already lighted lamp had a 50 per cent shorter latency and was larger in size than that produced by lighting a gas-filled lamp. The difference may be attributed to the difference in rate of reaching full intensity, the ultimate intensity being the same in both instances. The author correlates this effect of the rate of increase of intensity of light with his observation that in stimulation with flicker the first flash of light shortens the latent period of the retinal and cortical potential wave elicited by the subsequent flashes. This observation is at variance with results of earlier workers.

R. IRVINE.

Retina and Optic Nerve

A CASE OF TUBERCULOUS PAPILLITIS WITH ANATOMIC FINDINGS. H. D. LAMB, Am. J. Ophth. **20:** 390 (April) 1937.

Lamb gives the following summary of a case in which the condition presented by the patient was diagnosed as tuberculous papillitis:

"In a man 47 years old, a railway brakeman, there occurred a very pronounced swelling of the optic papilla and much cloudiness in the vitreous anteriorly and inferiorly to the optic nerve. Superiorly, the retina contained numerous hemorrhages. No significant process elsewhere in the body could be found as an etiologic factor. Because of increased tension and pain, it became necessary to enucleate the totally blind eye. Anatomically, the greatly thickened papilla was found to be infiltrated with islands of epithelioid cells and a few giant cells, surrounded by small lymphocytes and plasma cells. In the neighboring choroid, an extension of the process from the papilla had produced a single tubercle with an involvement of the adjacent retina."

W. S. REESE.

PARACENTESIS AND ATROPINE IN THE TREATMENT OF OPTIC AND RETINAL ATROPHIES. M. L. FOLK, Am. J. Ophth. **20:** 511 (May) 1937.

Folk gives the following conclusions:

"It is obvious that no definite conclusions can be drawn from this investigation: first, because the number of cases is too small; second,

because the period of observation is too short, and third, because no control group has been observed. However, certain impressions can be obtained even from a small series such as this, and my impressions may be stated as follows: (1) Cases of luetic optic atrophy in the early stages seem to be definitely benefited by the combined treatment of paracenteses and atropine. (2) Fairly advanced cases seem to derive only a slight benefit or at least a stay in the progress of the atrophy. (3) Well-advanced cases show no improvement at all. (4) In retinitis pigmentosa the improvement from the treatment is of only a temporary nature and the atropine has to be often repeated. (This thoroughly agrees with the views of Dr. Vele.) (5) Secondary atrophy following retrobulbar neuritis seems to receive very little benefit, if any, from the treatment. (6) The treatment is simple and harmless.

"This adjuvant in the treatment of optic atrophy is brought to the attention of the ophthalmologists of this country for the sole purpose of stimulating further clinical investigation so that a larger series may be accumulated from which more definite conclusions could be reached. The writer hopes to carry on this work and render a final report in the near future."

W. S. REESE.

VARIATIONS OF THE BLOOD PRESSURE IN THE CENTRAL RETINAL ARTERY IN CHANGES OF THE POSITION OF THE BODY OF HEALTHY PERSONS. A. KAMOGAWA, Klin. Monatsbl. f. Augenh. **97:** 611 (Nov.) 1936.

After an introduction on various methods of measuring the blood pressure and after discussing the bibliography in point, Kamogawa reports the results of his clinical research. The apparatus, the material and his methods of examination are described. Tables show data on the general and the retinal arterial blood pressure of thirty healthy persons in a sitting and in a recumbent position. Immediately after the subjects assumed a horizontal position the measurements were taken by means of the ophthalmodynamometers of Uyemura and Saganuma, and measurements of the brachial artery were made simultaneously. The author found an increase of 11.3 mm. of mercury for the systolic blood pressure and 11.3 mm. for the diastolic blood pressure in the central retinal artery immediately after change from a sitting to a horizontal recumbent position. The causes for this change of the blood pressure are the weight of the blood (and, secondarily, the change of the distribution of the blood in the body) and changes of the tonus of muscles and blood vessels caused by the change of position of the body; other less important causes may occur incidentally. The changes of the blood pressure in the brachial artery produced by the change of the position of the body are outside of standard errors of figuring.

K. L. STOLL.

RETINAL CYSTS AND THE ORIGIN OF HOLES IN THE RETINA: REPORT OF CASES. A. FUCHS, Klin. Monatsbl. f. Augenh. **98:** 145 (Feb.) 1937.

Fuchs reviews briefly the pathogenesis of retinal cysts. There is no distinct anatomic difference, in his opinion, between retinal cysts

and splitting of the retina. He refers to the case of a man aged 23 with von Hippel's disease, in which a cyst was formed by splitting of the retina; histologic data are added. Two cases of retinal cysts are reported, one that of a woman aged 47, and the other that of a man aged 57. In each case the cysts existed for a long time without leading to detachment of the retina. The large cyst disappeared in the first case; therefore, operative procedure need not be hurried in these cases. Fuchs reasons that the cyst formed possibly inward and that this prevented a large detachment; the ophthalmoscopic appearance, however, seems to contradict this conception. He explains why retinal cysts are transparent and as difficult to observe as splitting of the retina. The inner layers of the retina are tightened and thinned by an increased amount of fluid. The tension of the walls of the cyst counteracts the formation of an edema which would produce a whitish or opaque appearance of the retina. The tension produced by the accumulated fluid in the cyst in the first case changed, so that the walls of the cyst grew gradually more transparent and therefore less visible.

The origin and importance of holes in the retina are discussed in the second part. Holes in the retina, in Fuchs' opinion, originate mostly by simultaneous action, and less frequently by separate action, of two factors: (1) traction and changes in the vitreous and (2) degeneration of the retina. There may be other reasons for the occurrence of holes and ruptures of the retina, with following "idiopathic detachment." Formation of cysts must be distinguished from cystoid degeneration. The formation of cysts is characterized by progressive accumulation of fluid which produces a separation of the retina so that its walls become prominent outward and inward. This condition occurs rarely in the extreme periphery. Typical senile cystoid degeneration, on the other hand, begins at the ora serrata and consists in gaps within the tissue. These gaps form as a result of rarefication of the tissue and passive accumulation of fluid. Fuchs accepts Weve's explanation of the origin of tears in the ora serrata as a result of cysts. On the other hand, he disagrees with Arruga, who refused to accept the theory of distention of the retina as a cause of separation of the retina and choroid, because, Arruga contended, detachment of the retina is rare in young myopic persons, although their eyeballs are greatly elongated. Fuchs points out that the tissues of the eyes of these young persons are far more elastic than those of the eyes of older persons. He reports in detail the case of a woman aged 67 as an illustration of ocular distention. There was a defect in the fovea of each eye. The portion of the retina adjoining the superior temporal retinal artery was greatly rarefied, and the structure of the granular layer had been lost. This paravascular rarefication, ocurring on each side of a vessel and bridged over only by the vessel, is made responsible for the formation of a hole. Senile rigidity of the tissues will further the rarefication.

K. L. Stoll.

Trachoma

The Relationship Between Conjunctivitis and Trachoma. A. F. MacCallam, Brit. J. Ophth. **20:** 346 (June) 1936.

This is the published address of the president at the session of the League against trachoma held in Paris, May 9 to 15, 1936.

MacCallam gives the following definition of trachoma: "Trachoma is a specific contagious disease of the conjunctiva in man. It is chronic in nature. It is characterized by a subepithelial infiltration of the conjunctiva by a cellular exudate, which spreads to the cornea and to the tarsus. It is followed by cicatricial changes in the affected tissues."

He describes the clinical features of the disease, emphasizing the changes which aid in its diagnosis. He states that only in the first stage of trachoma is there difficulty in differentiating this disease from other forms of conjunctivitis. This difficulty is resolved by the detection of cellular infiltration and vascularization of the normally clear cornea at the upper fifth of its circumference.

There are no chemical or microscopic tests which when applied to the conjunctival secretion assist in making a diagnosis; nor would assistance be obtained by removing a portion of the conjunctiva for microscopic examination. In some cases, but not in all, light scraping of the conjunctiva removes some of the superficial cells, which when stained by Giemsa's method exhibit the cellular inclusions described by Halberstaedter and Prowazek; but these are found in conditions other than trachoma, e. g., in swimming-bath conjunctivitis and in the nongonococcic conjunctivitis of infants; nor can they invariably be detected in the first stage of trachoma; it is quite useless to search for them in the second stage.

The address concludes with an enumeration of the common, uncommon, rare and tropical conditions which on occasion may bear some resemblance to trachoma. It is only necessary to say that in the absence of infiltration of the normally clear cornea by a cellular exudate and in the absence of the vascularization characteristic of trachoma the condition under consideration may be considered nontrachomatous.

W. ZENTMAYER.

Tumors

LEIOMYOMA OF THE IRIS. A. D. FROST, Am. J. Ophth. **20**: 347 (April) 1937.

Frost discusses leiomyoma of the iris and some of the reported cases. He cites the case of a married woman aged 46 and gives the following summary:

"1. A case which must be regarded as leiomyoma of the iris is described. It is the second case in which the pathologic findings are sufficiently definite to justify this diagnosis. The other case was reported in 1923, by Verhoeff, who reviewed the literature and contributed an excellent description of the pathologic histology of this lesion.

"2. Two cases which have since been reported as leiomyoma by Velhagen and by Bossalino are questionable in that neither of these authors demonstrated the presence of the characteristic myoglia fibrils by differential staining.

"3. Clinically, leiomyoma is relatively benign. Its outstanding pathologic characteristics include a structure of interlacing, closely packed bundles of spindle cells with rod-shaped nuclei in palisade arrangement, displaying eosinophilic cytoplasm and myoglia fibrils."

W. S. REESE.

THE USE OF RADON IN THE TREATMENT OF METASTATIC CARCINOMA OF THE CHOROID. P. JAMESON EVANS, Brit. J. Ophth. **21:** 496 (Sept.) 1937.

The case described is unusual in that metastatic carcinoma, secondary to carcinoma of the breast, developed in each eye, occurring in the one eye two months before it was noted in the other. The first eye was excised, the fellow eye at that time being normal, and the second eye was treated by the application of radon seeds.

The patient was a woman aged 41 whose left breast had been removed two years previous to the appearance of the metastatic growth in the left eye. The eye was removed. The pathologic report on the intra-ocular growth was secondary adenocarcinoma. About five weeks later, vision began to fail in the right eye and quickly fell to 6/60. There was a large, pale, flat detachment of the retina, spreading from the optic disk downward and outward, below the line of the inferior temporal vessels, similar to that seen in the left eye prior to excision. The inferior rectus muscle was secured and cut, the posterior end being retained on a catgut suture. The lower half of the sclera was then exposed. Four radon seeds, having an initial activity of 1.72 millicuries each, were stitched to the sclera; two were placed 12 mm. back from the limbus and 10 mm. apart on each side of the inferior rectus muscle, and two 15 mm. back and 8 mm. apart. A second thread for the purpose of withdrawal was attached to each seed and brought out through the conjunctival wound, while the scleral sutures were brought forward through the lower lid and tied off in pairs, an inner and an outer pair, over rubber tubing.

Two months later, vision was 6/6. The retina was entirely flat, the yellow growth having disappeared, but there was widespread choroidal reaction with pigmentation, which appeared to be spreading in all directions and involved the macular area.

Four months later a fresh patch of new growth was seen adjacent to, and continuous with, the upper and outer margin of the disk. A second application of radon seeds was made. Two months subsequently vision equaled 6/12, and the retina was entirely flat.

The features of interest in this case are, briefly, these:

The occurrence of bilateral metastatic carcinoma of the choroid during a period of three months, two months elapsing between the incidence in the left eye and that in the right eye.

The confirmation of the pathologic changes in the case of the left eye and the exactly similar appearance of the right eye at a later date, which put the diagnosis of the condition of the second eye beyond doubt.

The method of application of radon seeds to the sclera.

The latent period, after the operation, of some two or three weeks before much appreciable change in the appearance of the growth took place; the progressive nature of this change over some two months, and the widespread choroidal reaction, which also was progressive for about the same period.

The complete replacement of the retina on the disappearance of the growth, with full return of the visual field and of visual acuity.

Absence of any sign of recurrence in the eye over a period of seven months.

The application of radon seeds a second time, resulting in disappearance of the tumor.

The gradually increasing glandular character of the metastatic growths as compared with the primary tumor of the breast.

The article is illustrated.

W. ZENTMAYER.

Therapeutics

RED-PALM OIL IN THE TREATMENT OF HUMAN KERATOMALACIA. W. R. AYKROYD and R. E. WRIGHT, Indian J. M. Research **25:** 7 (July) 1937.

Aykroyd and Wright determined the vitamin A activity of red palm oil by experimentally producing in rabbits a condition resembling clinical keratomalacia. They cured these characteristic lesions of the eye by giving the rabbits from 0.5 to 2 Gm. of red palm oil. They then carried out a clinical trial, using 10 minims (0.6 cc.) of the original oil in an emulsion as an average dose for children between 5 and 10 years of age, a suitable allowance being made for younger and older patients. This dose was given twice daily. Difficulties are encountered, one of which is the possibility that a beneficial effect in cases of deficiency may result from simply admitting the patient and placing him on a hospital diet. In three instances, however, the authors were enabled to treat and follow up patients suitable for observation, who remained living under the identical domestic conditions in which the syndrome developed. The only change in their daily routine was the addition of emulsion of red palm oil to their diet. In these the improvement was so definite that the investigators concluded that, so far as the strictly limited observation went, the red palm oil alone acted in a curative capacity, supplying the necessary factor or factors in the same way as cod liver oil had done previously. Most of the patients with keratomalacia treated in the hospital were infants and young children. Cessation of deterioration may be observed within a week, and definite improvement within a fortnight, after the commencement of treatment with the red palm oil. The average vitamin A content of seven samples of cod liver oil tested was about 300 micrograms of vitamin A per gram, while the carotene content of three samples of red palm oil averaged about 500 micrograms per gram. Most of the samples of cod liver oil were obtained by local purchase. One microgram of carotene and 1 microgram of vitamin A, as estimated by De's method, are roughly equivalent to 1 and 2.6 international units, respectively.

J. A. M. A. (W. ZENTMAYER.)

TREATMENT OF HERPETIC KERATITIS WITH BUCKY'S RAYS. M. M. BALTIN and Z. M. SEREBRIANY, Vestnik oftal. **10:** 688, 1937.

Irradiation with Bucky's rays was used for ninety-three patients during a period of one and a half years in Helmholtz' Eye Institute. Fifty-five patients suffered from herpes of the cornea, and twenty-six from dendritic, six from disciform, and six from superficial punctate, keratitis. The ages of the patients varied from 20 to 40 years, and males were predominately affected. The majority of the patients stated

that grippal infection preceded the ocular condition. Trauma of the eye as an immediate cause of herpetic keratitis was noted in only four patients.

The best results were obtained in herpes of the cornea (improvement in 89 per cent of the cases), particularly in those cases in which treatment was started in the early stage of the disease. The advantage of Bucky's rays over the roentgen rays is that they are absorbed by the superficial layers of the cornea and do not penetrate beyond it, and the danger of formation of cataract is therefore eliminated. The technic of the treatment is described in detail. The authors draw the following conclusions:

1. Bucky's rays in a correct dose act favorably in herpetic keratitis. The duration of the treatment is shortened considerably; the irradiation is painless and harmless.

2. The best results are obtained in early cases.

3. In deep keratitis the treatment does not produce the desirable effect.

4. In cases of recurrence repeated treatments can be given, as there is no accumulative action on the tissues of the eye.

5. The simple technic of the irradiation makes its use available in dispensaries as a routine treatment.

O. SITCHEVSKA.

Society Transactions

EDITED BY W. L. BENEDICT

AMERICAN MEDICAL ASSOCIATION, SECTION ON OPHTHALMOLOGY

WILLIAM L. BENEDICT, M.D., Rochester, Minn., *Chairman*

Eighty-Eighth Annual Meeting, Atlantic City, N. J., June 7-11, 1937

PARKER HEATH, M.D., Detroit, *Secretary*

ANGIOID STREAKS IN THE FUNDUS OCULI.

DR. WILLIAM L. BENEDICT, Rochester, Minn.

The condition now known as angioid streaks in the fundus of the eye was first recorded by Robert W. Dayne in 1889. Three years later Plange reported a condition, which he thought had not previously been described, which "bore a certain similarity to the disease known as retinitis striata but in etiology resembled retinitis proliferans." He noted a disposition to pigment in striae in the retina after hemorrhage, followed by changes, probably hyperplastic, in the supporting fibers of Müller. At the time Plange's report appeared, H. Knapp published a drawing of a condition similar to that described by Plange. Knapp did not discuss the changes extravasated blood may undergo in the retina but called attention to a "second case of the rare and puzzling formation of dark angioid streaks which Dr. Plange has described." Thus the name by which this condition has since become known was suggested by the conception that the dark radiating streaks were due to extravasated blood.

Many case reports published during the next thirty-six years gave valuable information regarding the nature of angioid streaks and their association with pathologic changes in the choroid and hemorrhages in the retina. A few cases were described in which hemorrhages were not found on repeated examination. I have frequently examined one patient who has been under observation for eight years and have never seen hemorrhages in the fundi. The streaks are always accompanied by choroidal changes of significant extent, although visual acuity may not be seriously impaired unless the macular region is involved. Angioid streaks have not been observed in children, and they are almost always bilateral. Explanations of angioid streaks have been offered by various authors, and while these explanations have been influenced somewhat by their own ophthalmoscopic observation, they have been based primarily on the views of previous writers. As the disease does not necessitate enucleation of the eye, pathologic examinations have not been made in undoubted cases. Conceptions of the histologic picture of angioid streaks have therefore been constructed from the ophthalmoscopic appearance of the fundi, the course of the disease, the effects on vision and constitutional disturbances. Pathologic changes in the choroid have been noted in nearly all reports of cases of angioid streaks of the fundus

oculi. These changes are extensive in many cases and are associated with hemorrhages in the choroid and the retina. The fact that angioid streaks appear in eyes in which hemorrhages are not seen at the time of examination does not prove that the streaks can be formed without hemorrhage. On the other hand, there is as yet no definite proof that extravascular extravasation of blood has any definite part in the formation of the streaks. In an eye which had been removed for relief of pain due to keratitis and secondary glaucoma, Verhoeff found marked fibrosis of the choroid and many projections or ridges comprising the inner layers of the choroid which were produced by cicatricial contraction of the fibrous tissue which had replaced the deeper layers. He had not seen the fundus before enucleation but noted angioid streaks in the fixed specimen. He thought that the angioid streaks could be explained by the ridges in the fibroid choroid and suggested as a descriptive designation for the condition now known as angioid streaks the term "fibrosis choroideae corrugans."

In September 1936 I enucleated the blind right eye of a patient with absolute glaucoma whose left eye showed typical angioid streaks and who had pseudoxanthoma elasticum of the sides of the neck and in the axillary folds. Because of cloudiness of the cornea, the fundus of the right eye could not be seen with the ophthalmoscope, but typical angioid streaks could be seen and photographed after enucleation and bisection of the globe. Microscopic examination of these sections, however, failed to show any pathologic changes that could be identified as angioid streaks. The retinal structures appeared practically normal, except for numerous small vacuoles resulting from fixation and embedding. The retinal vessels were patent and showed no sclerosis, though the patient had high blood pressure and came from a family afflicted with hypertensive disease. There was no retinal hemorrhage. The choroid showed perivascular lymphocytic infiltration about many of its vessels and heavy deposits of pigment surrounding the vessels and nerves. Sclerosis and obliteration of the choroidal vessels were not seen. The veins were large and thin walled. The arteries were all patent, and their walls were not thickened. The lamina vitrea was regular except for a few small hyaloid nodules. There was some fibrosis of the choroid, but folding or projection of the inner layer of the choroid was not present. There was perivascular lymphocytic infiltration in the episcleral vessels, which was most marked in the anterior sections, and a considerable amount of pigment was noted about the vessels and nerves traversing the sclera. In the sections stained with hematoxylin there was no evidence of an increased calcium content in the choroid or in the lamina vitrea. None of the proffered explanations of angioid streaks could be confirmed by microscopic examination of the sections of the enucleated eye.

THE VISUAL RAVAGES OF TRACHOMA. DR. HARRY S. GRADLE, Chicago, and DR. WALTER DE FRANCOIS, Harrisburg, Ill.

An analysis of the records of 2,713 consecutive cases of trachoma observed in the Southern Illinois Trachoma Clinics was made to determine the damage to vision caused by the disease and the extent of improvement that may be expected to follow adequate treatment. Of

the total number of patients, 17 had anophthalmos from one cause or another; therefore, a total of 5,409 eyes were studied. These eyes were divided into several groups according to visual acuity, as follows:

(*a*) Those with vision better than 20/50. Of the 5,409 eyes, 2,889, or 53.5 per cent, had visual acuity of better than 20/50.

(*b*) Those with vision between 20/50 and 20/200. Of the total number of eyes, 1,596, or 29.5 per cent, had visual acuity between 20/50 and 20/200. The reduction in vision was due to trachoma in 653 of that number, or 40.9 per cent. Under treatment, the vision in 250, or 39.8 per cent, improved to better than 20/50.

(*c*) Those with vision less than 20/200. Of the total number of eyes, 924, or 17 per cent, had vision of less than 20/200. The reduction in vision was due to trachoma in 566, or 61.1 per cent. Under treatment, the vision in 177, or 31.2 per cent, improved to better than 20/200.

In the Trachoma Clinics of Southern Illinois 7.8 per cent of the patients are industrially blind as the result of trachoma and its complications. Of the individual trachomatous eyes, about 30 per cent have a reduction in vision that interferes with satisfactory reading, about two fifths of the reduction being due to trachoma. Of the individual trachomatous eyes, 17 per cent are industrially blind, about three fifths of the reduction being due to trachoma. Vision can be restored to the useful point in from one fourth to one third of the eyes, the percentage varying according to the degree of loss and the length of time it has existed.

DISCUSSION

DR. C. E. RICE, Washington, D. C.: In a study of the case records of 1,600 patients with trachoma who were hospitalized in Missouri, it was found that there were 8.2 blind eyes to each hundred patients. That would figure out slightly more than 4 per cent of the patients blind if the two eyes were always affected to the same degree. Fortunately, that is not always true. Of about 4,000 patients whose case records were studied (not all patients were hospitalized), there were 12.5 per cent with vision of 20/200 or less in the better eye, due to trachoma. Dr. Gradle found 8 per cent of the patients with vision of 20/200 or less because of trachoma. It is of much interest that in Dr. Gradle's study it was found that approximately one fourth of those persons blind because of trachoma could have useful vision restored by proper treatment. The earliest case of severe trachoma I have seen was in a baby of 18 months. Pannus had already involved the greater part of both corneas. In this case, bilateral canthotomy and grattage were done after two months of hospital care. The final result was excellent. This case is cited to illustrate that trachoma can be very severe early in life. Another interesting point is that trachoma can remain unilateral. I have seen 12 patients with unilateral involvement to the extent that one eye of each patient was blind, while the other eye had normal visual acuity and no sign of a previous trachomatous infection.

AN UNCLASSIFIED TYPE OF OPTIC NEURITIS: REPORT OF CASES. DR. GRADY E. CLAY and DR. J. M. BAIRD, Atlanta, Ga.

This paper was published in full, with the discussion, in the November 1937 issue of the ARCHIVES, page 777.

SYPHILIS IN RELATION TO THE PREVENTION OF BLINDNESS. DR. CONRAD BERENS and DR. JACOB A. GOLDBERG, New York.

The case records of approximately 100,000 patients with ocular conditions seen in five clinics and hospitals in New York were studied. The Wassermann reactions were obtained for 2,237 of 5,969 patients whose case records indicated possible syphilitic infection. Reactions were positive for 444.

DISCUSSION

DR. E. V. L. BROWN, Chicago: These records are characterized by the writers of this paper as inadequate and inaccurate. The condition of some 6,000 of the 100,000 patients was diagnosed as syphilitic, but a Wassermann test had been made in less than half. Notes concerning the primary, secondary and tertiary nature of the syphilis present were lacking in 97 per cent of the cases, and a history of syphilis in the patient or his family was lacking in 98 per cent. Examinations of the eyes were likewise often inaccurate and insufficient. Interstitial keratitis was diagnosed in 240 cases, yet the fact that the Wassermann reaction was positive in only 54 per cent of them leads one to suspect that there were actually only about 150 real cases of interstitial keratitis in the group, because Igersheimer gives the Wassermann reaction as positive in 91.9 per cent. The conclusion is hard to escape that the condition in a large number of the cases was incorrectly diagnosed as interstitial keratitis. There is no reason to believe that the rest of the work was any better, and the records cannot by any stretch of the imagination be considered as a contribution to the knowledge of the subject of syphilis in relation to the eye, as given in the title of the paper. This is not the fault of the authors, who apparently recognized this fully and placed a good part of the blame on the lack of funds for social service. Four or five clinics had social service, but it was spread out pretty thin; for although it was supposed to cover matters of attendance, treatment, discharge and reference to other hospitals, to the department of health, to the department of hospitals, to a state hospital or to a private physician to record syphilis as a cause of death, even a single such note was found recorded in only 8 per cent of the cases. In one sentence the authors get at the heart of the matter, for they say that "much of the blame must be borne by the physicians." But they offer no remedy or suggestion of any kind. In my opinion, the reason for poor records is to be found in the widespread failure to recognize the dispensary as the crux, the heart, of the ophthalmic clinic, and the failure of the chief of service and, in particular, the head of the department to spend a minimum of three fourths of his time in the dispensary and secondly to give a good three fourths of the surgical work to attending men of middle rank on the staff. Too often he takes it all himself or gives it to the intern in unnecessary amount. If the competent and hard-working men of the middle rank are properly worked with and rewarded, they will do good work and make good records. If they are not given proper consideration, there will not be good work, good records or any other good activity in the dispensary. The condition is country wide, world wide. Every one knows the London, Paris, Vienna, Chicago and Boston clinics. These facts are certainly not peculiar to ophthalmic work. This paper makes the situation clear.

Dr. John Green, St. Louis: The authors quote Lewis and Holloway, who believe that serious diseases of the eye develop in from 50 to 75 per cent of syphilitic children. This estimate is, in my opinion, quite accurate. From 1916 to 1919 I made a study of 100 syphilitic children from the pediatric clinic of the Washington University Dispensary and the wards of the St. Louis Children's Hospital. It is believed that these 100 cases fairly represent the types of hereditary syphilis seen in a pediatric service and that the number and kinds of ocular complications are what might be expected in such a group. The clinical diagnosis was confirmed in every case by at least a two plus Wassermann reaction of the blood. Seventy-four of these children presented definite pathologic conditions in one or more of the ocular tissues or some derangement of ocular function. As adequate treatment of syphilitic women will almost certainly result in the birth of healthy babies, the means are at hand to eradicate all syphilitic diseases of the eye in infants and children. By this one means alone the incidence of blindness due to syphilis would be reduced 50 per cent.

To designate a disease of the eye as having a syphilitic origin in every case in which the serologic reaction is positive is a grave mistake, but it is equally reprehensible to neglect to have a Wassermann test of the blood made in certain cases in which the clinical manifestations do not certainly indicate syphilis. It is indeed amazing that with the ocular disease that almost invariably has a syphilitic basis, namely, interstitial keratitis, a positive Wassermann reaction should have been found in only 53.8 per cent of cases. This percentage is so much at variance with the ophthalmologic opinion that, with rare exceptions, interstitial keratitis occurring in children is of syphilitic origin that it points to the neglect of the serologic test in too large a number of cases of this disease.

Dr. Louis Lehrfeld, Philadelphia: A survey on syphilitic atrophy of the optic nerve has just been completed at the Wills Hospital in Philadelphia. A statistical investigation was made of 600 cases of syphilis affecting the optic nerve during a ten year period. The objective of the survey was to find out what happens to the eyesight of syphilitic patients who already show signs of involvement of the nervous system and to ascertain how effective present methods of treatment might be. The most important conclusion of the survey is that the present day treatment of syphilitic patients having involvement of the optic nerve is entirely unsatisfactory so far as improvement of vision is concerned. The only appreciable difference among the treated and the nontreated patients with syphilis who had degeneration of the optic nerve is that the nontreated patients became blind in five years while the treated patients became blind in eight years. Of a group of 350 patients, 250 were white and 100 Negroes. The preponderance of syphilitic atrophy of the optic nerve among the white patients as compared with the Negroes, in whom syphilis is five times more prevalent, may be a basis for suspecting that present methods of treatment may precipitate early atrophy of the nerve, while those who are lax in receiving treatment, particularly Negroes, are less likely to be affected. There is no doubt in my mind that early treatment of syphilis affecting the ocular structures should be instituted to save sight. There is also no doubt in my mind that the present methods of using arsenicals must

be revised if the percentage of blindness from syphilitic atrophy of the optic nerve is to be reduced. At the present moment the best method of preventing blindness from syphilis is to prevent the disease itself and not to place full reliance on the treatment of the disease.

TRYPARSAMIDE THERAPY FOR NEUROSYPHILIS AND ATROPHY OF THE OPTIC NERVE. DR. LEO L. MAYER, Chicago.

In a previous report the results of a year's study on 87 patients under active therapy with tryparsamide were published (Mayer, L. L., and Smith, R. D.: *Illinois M. J.* **65:** 258-264 [March] 1934). In the present communication I have included a reconsideration of these 87 patients treated with tryparsamide after a period of five years and, in addition, of all patients with neurosyphilis treated with tryparsamide at the Mandel Clinic of the Michael Reese Hospital and at the Northwestern University Medical School Dispensary since the time the drug was made available. At the Mandel Clinic the records of 28 patients treated with tryparsamide were found. In the group from Northwestern University Medical School there were 71 patients treated with tryparsamide during the five year period. From this study it must be concluded that the hesitancy in the use of tryparsamide, which has become widespread because of reports from certain authorities, does not have a firm base on which to stand.

DISCUSSION

DR. FREDERICK C. CORDES, San Francisco: There can be no doubt that the use of tryparsamide carries a certain danger comparable to that encountered in the use of any powerful drug, including arsphenamine. In just what manner this damage occurs is still unsettled. In considering this problem, two factors should be borne in mind: 1. Certain patients are sensitive to tryparsamide, as they may be to other drugs. 2. At times syphilitic atrophy of the optic nerve has a tendency to progress rapidly without the use of any specific therapy. It is rather generally conceded that in cases in which there is no damage to the optic tract the risk is slight, provided one is alert to the early warning of the subjective symptoms or objective signs. When symptoms appear, one must assume that the patient is sensitive to the drug, and in such cases it must be discontinued or used with a great deal of discretion. The results in this series of cases coincide with my experience that atrophy of the optic nerve in itself is no contraindication to the use of tryparsamide provided the patient is carefully observed for evidence of sensitiveness to the drug.

DR. WALTER I. LILLIE, Philadelphia: The number of cases presented is large, and the period of treatment is of sufficient duration not only to obtain a good clinical conception of the value of tryparsamide as a therapeutic agent but to support my contention as well as the contentions of many others that tryparsamide is not more dangerous from the visual standpoint than other preparations used in the treatment of syphilis of the central nervous system. Proper ocular supervision should be instituted for all persons treated, regardless of the therapeutic agent, as it is a well established fact that syphilis alone may and does cause progressive damage to the optic nerves, with resulting loss of peripheral

or central vision, or both. No one has definitely proved that tryparsamide or any other arsenical is neurotropic.

The type of changes occurring in the visual field before, during or after a proper therapeutic regimen has been instituted are similar to those occurring in untreated persons with syphilis, and as yet no pathognomonic defect in the visual field due to tryparsamide has been demonstrated. I believe, as does Dr. Mayer, that suggestion may play an important part in the production of subjective symptoms, while the organic changes are best explained by a direct syphilitic process in the optic nerves, namely, perineuritis. If tryparsamide is of value in arresting active syphilis of the central nervous system, it should also be of value in arresting active inflammation of the retina, choroid or optic nerve, and the presence of the latter should be no contraindication to its use. I am sure that ophthalmologists are all agreed that an untreated active syphilitic process of either the central nervous system or the visual apparatus has an unfavorable prognosis, so that any antisyphilitic therapeutic agent which will arrest or improve the condition should be used regardless of the pathologic condition existing when the therapeutic regimen is instituted. Reliable statistics prove conclusively that in inadequately treated or untreated syphilis of the central nervous system the occurrence of blindness due to atrophy of the optic nerve is about 35 per cent. The comparison of this percentage to the reported 2 to 10 per cent of blindness occurring during treatment with tryparsamide suggests that tryparsamide is preventing the development of atrophy sufficiently to affect the central visual acuity in about 25 per cent of the cases.

Dr. Leo L. Mayer, Chicago: If the pretherapeutic status is not recorded, the progress and final results obtained have little basis for comparison. The plea of Dr. Cordes for the study of more large series of such syphilitic patients certainly has my endorsement. Dr. Lillie has also emphasized the necessity of proper ocular supervision of the neurosyphilitic patient, regardless of the therapeutic agent used. I agree with Dr. Lillie. According to my experience no characteristic defect of the visual field has been noted after treatment with tryparsamide. It is also important to emphasize the fact that perimetry must be included as an important factor in the treatment of neurosyphilis. I wish to add another case to this group, to which Dr. Gifford called my attention before I left Chicago. A patient had come to the clinic at Northwestern University for treatment with tryparsamide, and the visual fields, the fundi and the visual acuity were studied. He received six injections of tryparsamide, and when he returned to the clinic after the sixth injection the visual fields were reduced to 5 degrees of the center in each eye. The visual acuity was not reduced, as there was no central scotoma. I simply wish to add that here is one case in which it seems that there might have been an effect from the drug itself.

Ocular Disturbances Associated with Experimental Lesions of the Mesencephalic Central Gray Matter, with Reference to Vertical Ocular Movements. Dr. Ernest A. Spiegel, Philadelphia, and Dr. Norman P. Scala, Washington, D. C.

This paper was published in full, with the discussion, in the October 1937 issue of the Archives, page 614.

NEAR REACTON OF THE PUPIL IN THE DARK: A QUANTITATIVE STUDY. DR. F. HERBERT HAESSLER, Milwaukee.

This paper was published in full, with the discussion, in the November 1937 issue of the ARCHIVES, page 796.

ACCOMMODATION AND THE AUTONOMIC NERVOUS SYSTEM. DR. DAVID G. COGAN, Boston.

This paper was published in full, with the discussion, in the November 1937 issue of the ARCHIVES, page 739.

LATE RESULTS OF EXTRACTION OF CATARACT. DR. EDWARD JACKSON, Denver.

This paper was published in full, with the discussion, in the September 1937 issue of the ARCHIVES, page 363.

FORMATION OF DRUSEN OF THE LAMINA VITREA. DR. BENJAMIN RONES, Washington, D. C.

This paper was published in full, with the discussion, in the September 1937 issue of the ARCHIVES, page 388.

BLEPHAROPTOSIS. DR. EDMUND B. SPAETH, Philadelphia.

In this paper I have emphasized the pleomorphous demands for surgical treatment of blepharoptosis. With the various structures of muscles available, I feel that the different indications for operation can be grouped into subdivisions for maximum results and further that these indications demand definite surgical procedures.

The utilization of the occipitofrontalis muscle has as its indication a certain inflexible group of conditions; the same applies to the utilization of the levator muscle, these indications being subdivided into those for which operation is performed through the anterior surface of the lid, as with the Everbush technic, and those for which operation is performed through the posterior surface of the lid, as with Blascovic's technic; third, the utilization of the superior rectus muscle has similar positive indications and contraindications.

I feel that as much attention should be directed to the differential diagnosis of ptosis from a surgical standpoint as is now directed to the surgical treatment of glaucoma and cataract.

DR. FERRIS SMITH, Grand Rapids, Mich.: The great majority of cases of blepharoptosis may be easily classified as to causative defect and an appropriate corrective procedure selected. The net of this consideration may be set up as follows: There are two objectives: to obtain function and to produce a cosmetic result, the latter consequent on the former. Lesions resulting from trauma, in which both muscles are paralyzed, require the careful study and skilful management indicated by Dr. Spaeth, while those resulting from lesions of the central nervous system may require similar consideration, or, more frequently, no consideration at all.

DR. DANIEL B. KIRBY, New York: I examine the width of the palpebral fissure in the primary position and then compare it with the

width when the eye is directed upward and again when the eyes are directed downward. I also take pictures of the patient for a photographic report in every case. I examine the length of the fissure, the horizontal and also the marginal length as applied to the lower lid. An ideal case is one of congenital ptosis in which there is partial development of the function of the levator muscle or one of acquired ptosis in which there is a partial remnant of the function of the levator. In these cases the resection procedure as applied to the levator muscle by the conjunctival route is indicated. In cases in which there is complete or almost complete paresis of this muscle with a palpebral fissure which actually narrows when the patient looks up because the lower lid follows the globe in elevation and the upper lid does not, there is a definite indication for the employment of the Motais principle of transplantation of the superior rectus muscle. In cases in which there is complete paralysis of the levator and superior rectus muscle and in addition paralysis of the inferior oblique, the condition is called paralysis of elevation by Dr. Wheeler. The eye is in a position of hypotropia and cannot be used even though the ptosis is corrected. It is necessary to lift both the globe and the eyelid, using the procedure devised by Dr. Wheeler of resection and advancement of the superior rectus muscle and advancement of the inferior oblique over the orbital margin. This will tense the remnants of the muscles even though no muscular action is produced and will elevate the globe. Then the Motais or Parinaud principle may be employed to elevate the lid. Cases of ptosis due to trauma or a new growth require special consideration. This covers the field of ordinary surgical treatment for ptosis and leaves no need for the employment of the frontalis muscle in any case. It is true that the average patient with ptosis will hold back his head, arch his brows and wrinkle his forehead in the effort to get the curtain of the lid above his pupil. This is an undesirable feature of the case and gives the typical curious expression. After the use of the frontalis muscle, this expression is continued. The upper eyelid normally slides back over the convexity of the globe, as does the top of a roller desk. Attachment to the frontalis muscle lifts it in an unnatural, straight, vertical manner.

AMBLYOPIA WITH VASODILATORS. DR. WALTER F. DUGGAN, New York.

The results obtained with acetylcholine roughly parallel those obtained with sodium nitrite, administered intravenously. While improvement was slightly faster in the cases in which acetylcholine was used, it was slightly better in the cases in which sodium nitrite was employed. However, the vision was as a whole more reduced with sodium nitrite than with acetylcholine, so that, all factors being taken into consideration, sodium nitrite seems to be slightly more effective than acetylcholine in the treatment of tobacco amblyopia. This difference is said to be due to the fact that sodium nitrite is destroyed less rapidly than acetylcholine in the body, so that its effect is maintained longer. Since both acetylcholine and sodium nitrite bring about a more rapid return of vision in cases of amblyopia than some of the previously used methods of treatment, this lends further support to the hypothesis that tobacco amblyopia is due primarily to a vascular spasm in the optic pathways.

DISCUSSION

DR. LAWRENCE T. POST, St. Louis: The most important question involved in Dr. Duggan's paper is whether vasodilators are valuable in the treatment of tobacco amblyopia. The author and others have previously discussed the hypothesis that this disease is due to a vascular spasm in the visual pathway and that vasodilators shorten the time of return to normal in these cases, but I think these points are still unproved. Several speculations regarding the possible value of vasodilators in the treatment of tobacco amblyopia occur to me. If it is assumed that the symptoms are produced by a prolonged constriction of the blood supply of the visual apparatus, does it necessarily follow that relief from this constriction, if obtainable, would restore normal function? In diseases involving constriction of the peripheral vascular system of the extremities, though dilatation of the vessels of the extremities can be caused by sodium nitrite or acetylcholine, this does not help the disease condition. But more fundamental than this is the lack of proof that these vasodilators do actually increase the vascular bed of the visual system. There is considerable evidence that they do not dilate the vessels of the retina. Another theoretical point against the likelihood of this therapy being valuable in the treatment of a relatively chronic or at least a nonacute condition is the evanescent action of these vasodilators. At most they probably act only a few moments, and in the author's cases they have been used only once a day. In a previous paper the author, in considering the action of acetylcholine, remarked on the transitory nature of its action and referred to the fact that the action is much prolonged in the presence of physostigmine even in small quantities. One of the authors whom he quotes used physostigmine as a preliminary to acetylcholine. Since it is reasonable to assume that a prolongation of action is desirable, this combination might be useful. In the medical service at Washington University, acetylbetamethylcholine has been found to have a much longer action than acetylcholine and is being used in preference to the latter drug. It is suggested that if vasodilators are proved to be valuable in the treatment of tobacco amblyopia, this drug might be found advantageous. The possibility of improvement by vasodilators must be further considered, but other factors that might be important in quick recovery should be carefully sought.

DR. WALTER F. DUGGAN, New York: Since patients have noted that after any period of physical stress their vision seems to decrease, it has been my custom to allow the patients to rest a short time before the vision is tested. With improvement in the vision, there is a definite decrease in the size of the scotoma. Often patients say that their vision is improving, and, while the visual acuity may be the same, the scotoma will be found to be definitely smaller. An analogous case, which I saw with Dr. Knapp, was one of spasm of a branch of the central retinal artery in which the spasm, with a defect in the visual field, had lasted for two months. The spasm suddenly disappeared one night, and the patient came in a few days later with a greatly improved visual field and visual acuity. I know that reports have appeared stating that vasodilators do not dilate the retinal vessels. In the first place, I do not

think the retinal vessels are involved in tobacco amblyopia. Also, if the retinal arteries are of approximately normal size, any slight increase in diameter would not be apparent. I have seen very constricted retinal arteries dilate with this treatment. The vascular bed must be increased, because in 2 or 3 of my cases the intravenous administration of sodium nitrite was followed by a definite fall in blood pressure of from 20 to 40 mm. of mercury, which was maintained for several hours. Acetylcholine acts only a few minutes on the blood presure. The pressure will drop 10 or 20 mm. and then be back to normal in fifteen or twenty minutes at the most. I think the use of physostigmine before the administration of acetylcholine would help.

IMPORTANCE OF DIET IN THE ETIOLOGY AND TREATMENT OF TOBACCO-ALCOHOL AMBLYOPIA. DR. FRANK D. CARROLL, New York.

This paper was published in full, with the discussion, in the December 1937 issue of the ARCHIVES, page 948.

THE DOMINANT EYE: ITS CLINICAL SIGNIFICANCE. DR. WALTER H. FINK, Minneapolis.

This paper will be published in full, with the discussion, in a later issue of the ARCHIVES.

GERMAN OPHTHALMOLOGICAL SOCIETY

DOZENT DR. M. BÜCKLERS, Tübingen, *Reporter*

Fifty-First Annual Meeting, Heidelberg, July 6-8, 1936

TRANSLATION BY PERCY FRIDENBERG, M.D., New York

Second Scientific Session

Monday, July 6, 1936, 3 p. m.

PROF. W. MEISNER, Cologne, *Chairman*

DISCUSSION ON REPORTS I, II AND III[1]

PROF. BRUNO FLEISCHER, Erlangen: The intensive investigation of Dr. Bücklers on hereditary corneal dystrophy, especially his discovery of a form which apparently is transmitted as a recessive character, is welcome. However, as long as an essential differentiation (perhaps of a chemical or a pathogenic nature) has not been demonstrated, the differentiation of certain types of corneal dystrophy which are characterized by definite morphologic aspects or by varying modes of hereditary transmission does not necessitate abandoning a designation

1. This discussion was omitted from the proceedings of the Second Scientific Session published in the September 1937 issue of the Archives (vol. 18, p. 482). It should precede the report by Dr. W. Clausen, of Halle, on "The Role of the Ophthalmologist in the Prevention of Hereditary Diseases."

such as familial corneal degeneration, which, after all, has been introduced generally and which sums up the essential feature of the condition. One does not need to consider it anything more than a deposit of certain pathologic products in the corneal tissues caused by some anomaly of metabolism. Not only the crumbly (*bröckelige*) but the spotty (*fleckige*) type of corneal dystrophy has a dominant heredity, if I remember correctly.

PROF. KARL LINDNER, Vienna: I am definitely opposed to the conception of spontaneous detachment of the retina as a phenomenon of heredity. This process is the result of several partial or cooperating factors, only one of which can be looked on as inherited. In regard to myopia, I hold to my original idea that close work plays an important role in its progress. If one were to consider progressive myopia as a purely hereditary condition, any attempt at therapeutic or hygienic measures might just as well be given up as useless. But, as of old, one's most important duty is still the careful correction of the myopia, and in case it progresses, the limitation of the use of the eyes for close work.

PROF. WALTER LÖHLEIN, Berlin: Do previous experiences in biogenetic research on the eye offer the hope of gaining clues as to whether the degree of manifestations of a given pathologic (hereditary) disposition will be intensified or mitigated in the succeeding generations? Such a knowledge would be of the greatest practical importance, especially in cases in which an actual hereditary blindness is not present but in which the parents require advice in regard to future offspring. This question is raised most persistently when the manifestations of a hereditary ocular lesion vary noticeably in members of the same family. As an example, a family is cited in which the first child was born with normal eyes and a second child had aniridia, nystagmus and bilateral blindness at birth. The mother's eyes were normal. In the father's eyes, however, there was found as the basis for the pathologic (hereditary) disposition a unilateral pit formation (*Grubenbildung*) on the disk, with normal vision and field.

DOZENT DR. MAX BÜCKLERS, Tübingen: I cannot support Professor Fleischer's contention that the old designation of familial corneal degeneration or dystrophy should be retained, for the very reason, if for no other, that formerly a number of quite unrelated or at least differing clinical pictures were classed together as variations of manifestations of one and the same basic form of ocular disease. In the interests of racial and social hygiene alone and of a clear understanding of this aspect of the problem, it is absolutely essential to separate fundamentally the three forms of hereditary corneal dystrophy. Lenz objects, and with good reason, to the use of the term "degeneration" on the ground that it has quite a different significance in biogenetics. In the last analysis, every hereditary disease or anomaly is "familial." One does not speak of familial opacities of the lens. In all the 10 family trees of patients with spotty corneal dystrophy, of which I was able to bring with me only the 2 smallest, a recessive heredity can be demonstrated without a single exception. In 1 family an affected father had several sick children, but this was explained by the fact that he had married a blood relation who was probably a carrier or transmitter.

FRIEDRICH OEHLKERS, Freiburg in Breisgau: The term "mosaic inheritance" which has been used in the course of general remarks on my report has a definite meaning in general biogenetics. It is not used to specify a modification of gene combinations (*Umkombination*) or different manifestations of a biogenetic nature but only to denote highly unstable (*labile*) genes which undergo variations within a single individual.

O. VON VERSCHUER, Frankfort-on-Main: The concept of a sex-linked hereditary transmission has become accepted by regular usage in the science of genetics during the past twenty-five years. A change in this conception cannot well be accomplished. In heredobiology the concept of coupling (*Koppelung*) also has a definite meaning. Those hereditary anlagen are considered as coupled which are located in one and the same chromosome. This concept must be differentiated from that of correlation, by which is understood, to begin with, the purely quantitative relations between two or more events. Correlation may be the result of similar hereditary dispositions or of similar environmental factors. In every instance of correlation this possibility must be borne in mind. Special biogenetic research is essential to determine whether one is dealing with a common or a shared biogenetic basic factor, or, on the other hand, whether there is some other possible explanation for the correlation. To the question as to whether the persistence, energy or intensity (*Durchschlagskraft*) of a hereditary anlage varies or is constant, no definite answer can be given which can be generally and universally valid and hold good in all cases. There are hereditary anlagen which present an extraordinarily constant manifestation through many generations and others that vary in their manifestations. It is impossible, however, to predict whether one is to expect variability or constancy in a given case or whether the manifestation is to be marked or slight. In order to do so, first more accurate knowledge of the biogenetic significance of the hereditary anlagen will be necessary.

J. P. WAARDENBURG, Arnhem, Netherlands: The question of glioma and its biogenetic implications is by no means a simple one. Undoubtedly, in a considerable number of cases the condition has a true hereditary basis. When the parents of a subject with glioma are blood relations or when bilateral or unilateral gliomas have occurred in a family in the ascendency, it stands to reason that sterilization must be considered. It is not clear to me how the matter stands in regard to the many nonfamilial cases which are reported by Stock and also by Hemmes from the Netherlands. Tumor formation may depend on somatic mutation, too, which is not hereditary eo ipso. Thus, a generally applicable and practical fundamental law cannot be laid down. As to Professor Lindner's remarks on myopia, I am convinced that the modifying influence of close work is a slight one but that there are many reasons for giving it only a minor practical importance. It would take up too much time to go into detail in support of this position, so I shall follow Professor Lindner's course in this respect and merely state my belief without confirmatory data. I agree with Bartels in disapproving of the sterilization of affected males, on account of Lossen's law. It would be important for the sisters of such persons not to reproduce their

kind. It would be better not to characterize retinal detachment as a hereditary malady. So many requirements have to be fulfilled before a detachment actually takes place that it is no wonder that even in the familial cases one finds an irregular dominance. In the case in which the condition is hereditary the tendency to degenerative processes in the retina and the changes in the vitreous, which is embryologically so closely connected with the retina, are to be considered as hereditary disposition. I should like to suggest to Dr. Bücklers that suitable Latin names be used for the types of corneal degeneration and that the term "familial" be abandoned entirely.

(To be continued)

Book Reviews

Introduction to Physiological Optics. By James P. C. Southall, Professor of Physics, Columbia University. Price $5.50. Pp. 427, with index, table of contents and 135 diagrams and illustrations. New York: Oxford University Press, 1937.

This work covers briefly almost every branch of physiologic optics and is to some extent a condensation of much of the material found in larger works, e. g., Helmholtz' "Physiologic Optics," to which frequent reference is made. Unlike the latter, this book is up to date and incorporates the latest findings in the field of physiologic optics.

The book has, on the whole, the usual rigidly scientific presentation of facts and theory for which Southall is famous, though minor errors of fact are found here and there, largely relating to fine points of anatomy, pure physiology and practical ophthalmologic application. The style is often light and occasionally semipopular. This is probably due to the fact that the book is intended for a variety of readers, including "the large class of intelligent laymen," Incidentally, the latter, more than any one else, will be confused by the author's definition of far-sightedness as synonymous with presbyopia, rather than with hyperopia, as is usual.

Some general statements and recommendations will be seriously questioned by ophthalmologists, e. g., that "latent hyperopia disappears entirely when the patient is refracted by skiascopy or ophthalmoscopy in a dark room," the advice "never to prescribe plus lenses in facultative hyperopia or cylinders in astigmatism until symptoms begin to appear" or the statements "that duction tests with prisms measure the strength of the extrinsic ocular muscles," and that in presbyopia "less muscular exertion is needed to produce whatever accommodation is still possible."

The chapters on the nature and mechanism of binocular vision, stereoscopic vision, and color and color theories are especially complete. They contain the fundamentals of the various theories and practices underlying these subjects, partly from the standpoint of practical application, but largely from the standpoint of research. A short chapter on rod and cone vision is a well balanced summary of the facts and interpretations which have been accumulated in the past several years, notably by Hecht and his co-workers, and which are scattered in various physiologic and psychologic magazines.

The principal shortcoming of the book from the standpoint of the ophthalmologist is the uniform mathematical approach to the subject. There is an abundance of formulas and symbols, usually Greek, bearing on almost every phase of the subject discussed. Doctors as a rule are poor mathematicians and are probably wholly unaware of the physicist's thrill in juggling around symbols, equations and logarithmic curves. For this reason much of the really fine features of the work will be lost on them, though unquestionably relished by other readers, e. g., "physicists, technical experts in physiological optics and others." In a book written for so wide a variety of readers as this one is such lapses are inevitable.

There is, however, enough easily digestible material of general scientific interest as well as of special ophthalmologic interest to make the book well worth having for reference and consultation.

JOSEPH I. PASCAL, M.D.

In the preface the author stated that this book is intended for intelligent laymen. He added:

> At the same time I venture to hope also that technical experts . . . can yet read with profit and enlargement of mind a volume in which both the facts and the theories built upon them are set forth in consistent and logical order. This latter group includes not only specialists in physics, in physiology and biophysics and in psychology but also professional ophthalmologists, illuminating engineers and many representatives of the arts and industries as well as artists and painters, . . .

The extent to which the author has carried out his intention is remarkable. One would certainly believe that the book would be valuable to the specialists mentioned, although the "intelligent layman" and indeed some of the specialists might have some little difficulty with the geometric optics in the first two hundred pages and the analytic geometry in the discussion of colorimetry.

The title of the chapters of the book are:

I. The Organ of Vision
II. The Optical System of the Eye
III. Correction Eye-Glasses
IV. Hyperopia, Myopia and Astigmatism
V. Movements of the Eyeball in Its Socket
VI. Nature of Binocular Vision
VII. Rod Vision and Cone Vision
VIII. Colour Vision and Colorimetry
IX. Concerning Theories of Colour Vision
X. Temporal and Spatial Reactions of the Organ of Vision

An analysis of the contents of the book indicates that over half of the material is treated from a physical or mathematical point of view. And it is in this treatment which Professor Southall excels. Some knowledge of mathematics is advisable for reading the portions of the book which deal with the optical system of the eye, glasses, ametropia, ocular movements, stereoscopes and colorimetry.

About one third of the book is devoted to the physiologic aspects of physiologic optics, including color vision, accommodation and convergence, rod and cone vision and temporal and spatial reactions of the eye. In general, the physiologic treatment is more elementary than the physical.

The remaining sixth of the book deals with anatomy and physiology of the eye and the psychology of vision.

Since, as the author stated in his preface (p. v), "the material for this volume has been compiled from a course of lectures in physiological

optics which I have given in Columbia University for undergraduate students over a long period of years," it is clear that only the more elementary theories can be presented on many subjects. This is, of course, excellent pedagogic technic, but it is possible that the book would be somewhat improved by giving references to the more advanced views in the literature which the ambitious reader might examine. Thus, after the excellent discussion of the movements of the eyes and of false torsion, Professor Southall gives the impression of denying the existence of real torsion by stating (p. 176): "Obviously, therefore, having only two degrees of freedom as thus indicated, the globe of the eye or the eyeball cannot turn around the line of fixation; although curiously enough most authorities persist in maintaining the contrary." Here a few references might be given to real torsion, such as the following:

Hofmann, F. B., and Bielschowsky, A.: Ueber die der Willkur entzogenen Fusionsbewegungen der Augen, Arch. f. d. ges. Physiol. **80**:1, 1900.

Ames, A.: Cyclophoria, Am. J. Physiol. Optics **7**:3, 1926.

Herzau, W.: Ueber das Verhältnis von erzwungener Vertikaldivergenz und Rollung bei Fusion, Arch. f. Ophth. **122**:59, 1929.

Verhoeff, F. H.: Cycloduction, Tr. Am. Ophth. Soc. **32**:208, 1934.

Again, in dealing with the mechanism of accommodation the theory of Helmholtz is the only one presented. Perhaps reference should be made to the promising theory of dual innervation of the ciliary muscle, considered by the following authors:

Henderson, T.: The Anatomy and Physiology of Accommodation in Mammalia, Tr. Ophth. Soc. U. Kingdom **46**:300, 1926.

Hudelo, A.: Mécanisme de l'accommodation et myopie diabétique, Arch. d'opht. **47**:70, 1930.

Byrne, J. G.: Studies on the Physiology of the Eye, London, H. K. Lewis & Co., Ltd., 1933.

Nicolai, C.: Der Mechanismus der Akkommodation, Klin. Monatsbl. f. Augenh. **94**:617, 1935.

Cogan, D.: Accommodation and the Autonomic Nervous System, Arch. Ophth. **18**:739 (Nov.) 1937.

Similarly, in the discussion of binocular vision, it is stated (p. 211) that "when the retinal images of one and the same object do not correspond, a double image will be seen." This simplified exposition is, of course, contrary to the views of Bourdon and Verhoeff, among others, which are cited in the following references:

Bourdon, B.: La perception visuelle de l'espace, Paris, 1902, p. 212.

Verhoeff, F. H.: A New Theory of Binocular Vision, Arch. Ophth. **13**:151 (Feb.) 1935.

Again, in treating of the Pulfrich phenomenon, Southall advances the usual interpretation based on intensity difference between the two eyes. Perhaps here reference should be given to the possibly more important factor of the relative state of adaptation of the two eyes, as in the following reference:

Granit, R.: Report of a Joint Discussion on Vision, Cambridge, 1932, p. 235.

Almost all of the treatment of rod and cone vision and critical flicker frequency is discussed from the point of view of Hecht. This makes for a unified presentation, but it might be advisable to give the reader references to the more advanced theories. For example, in discussing Hecht's theory of flicker it is said that "the flicker fusion frequency seems to be directly proportional to the concentration x of the photosensitive substance." Hecht, however, is dealing with a special case in which the wave form is rectangular, the dark phase of zero intensity and the dark and light phases of equal length of time. Under these restricted conditions x may be proportional to the maximums of $\frac{dx}{dt}$. Since $\frac{dx}{dt}$ rather than x may well be the controlling factor, the enquiring reader might appreciate references to more thorough treatments of the problem, such as the following:

Ives, H.: A Theory of Intermittent Vision, J. Optic. Soc. America **6**:343, 1922.

Cobb, P.: Some Comments on the Ives Theory of Flicker, J. Optic. Soc. America **24**:91, 1934.

Again (p. 404), it is said that "stereoscopic lustre is due entirely to difference of illumination as seen by the two eyes in conjunction." This suggests that "difference of illumination as seen by the two eyes in conjunction" is both a necessary and a sufficient condition for the production of luster. This factor does appear to be necessary, but it is not sufficient, as may be demonstrated by the failure to get stereoscopic luster when a black field is presented to one eye while a white field with no contours is presented to the other eye. Some readers may wish to look into the difficult problem of the effect of contours on luster as discussed in the following article:

Kaiser, H.: Compendium der physiologischen Optik, Wiesbaden, C. W. Kreidel, 1872, pp. 311 and 312.

As Professor Southall said (p. vi): "However, defects of omission can at least be supplied in a future edition provided the book should be good enough to warrant a revision." If, then, Professor Southall could, without sacrificing his powerful didactic style, make some reference to alternative views, the unaided reader would benefit.

Covering the broad field that it does, the volume would appear to be excellent for use as a text in conjunction with lectures or a seminar on physiologic optics, as it presents in clear style exactly what the title implies, an "Introduction to Physiological Optics."

The unassisted reader might draw some false conclusions, but this difficulty may be readily overcome by some modifications.

ELEK JOHN LUDVIGH, PH.D.

Pharmacopoeia of the Government Ophthalmic Hospital, Madras. By Lieutenant-Colonel R. E. Wright and Rao Bahadur K. Koman Nayar. Price 14 annas. Pp. 37, interwoven. Madras, India: Government Press, 1937.

This publication is a formulary of remedies used in diseases of the eye, both locally and generally, consisting of drops, injections, lotions, oils, ointments, pigments, powders and tablets. The collection is very useful and handy.

ARNOLD KNAPP.

Die Kuppelungen von Pupillenstörungen mit Aufhebung der Sehnenreflexe. By F. Kehrer. Price, 4.60 marks. Pp. 56, with 2 illustrations. Leipzig: George Thieme, 1937.

In 1932 Adie collected the bibliography on a condition described as a pupillary disturbance, "pupillotonia," associated with the abolition or reduction of tendon reflexes, particularly of the knee and ankle. This syndrome is also known in the literature as pupillotonia, pseudotabes and constitutional areflexia and now is the subject of this monograph by Prof. F. Kehrer, director of the clinic for nervous diseases in Münster, Germany. The debatable question is, How can these symptoms in widely separated parts of the body be brought under a common pathologicogenetic or causal relation? The subject is treated under the following headings: pupillotonia according to Behr and Adie; pseudotabes; accommodation in pupillotonia; Adie's syndrome; forms of pseudotabes; so-called constitutional areflexia, and other symptoms of pupillotonic pseudotabes. The author comes to the conclusion that the so-called Adie syndrome is only one of a group of symptom complexes suggesting a lesion of a closely confined area in the parasympathetic and sympathetic nervous systems and is produced by a variety of causes. It is one of several syndromes referable to the nervous system which can readily extend to include an adjacent area; it is a group of symptoms but not a disease.

Abnormal wideness of the pupils or occasional accompanying disturbance of accommodation usually brings the patient to the physician. A thorough examination of the eyes and nervous system should be made. The spinal fluid should be carefully examined, and all possible causes for pseudotabes must be investigated.

ARNOLD KNAPP.

Routine Methods of Treatment as Employed from Time to Time in the Government Ophthalmic Hospital, Madras. By Lieutenant-Colonel R. E. Wright and Rao Badhadur K. Koman Nayar. Price, 1 rupee. Pp. 33, interwoven. Madras, India: Government Press, 1937.

This book is a compilation of the methods of treatment which are used in the Government Ophthalmic Hospital, at Madras, India, and serves as a convenient memorandum for postgraduate students who are attending the practice of the hospital. The treatment for protein shock, tests and treatment for tuberculosis, antisyphilitic treatment, narcosis, nonoperative treatment of glaucoma (excellent) and trachoma are only a few of the items which are described.

A great convenience for the student and invaluable for the practitioner, as the material and information presented is often difficult to find, this little book brings the methods which have been approved of by the directing surgeon of the hospital from his vast clinical experience.

ARNOLD KNAPP.

Directory of Ophthalmologic Societies *

INTERNATIONAL

International Association for Prevention of Blindness

Honorary President: Prof. F. de Lapersonne, 217 Fauborg St. Honoré, Paris.
President: Dr. P. Bailliart, 66 Boulevard Saint-Michel, Paris, 6e.
Secretary-General: Prof. M. Van Duyse, Université de Gand, Gand, Prov. Ostflandern, Belgium.
All correspondence should be addressed to the President, Dr. P. Bailliart.

International Ophthalmologic Congress

Secretary: Dr. E. Marx, Costzeedijk 316, Rotterdam, Netherlands.

International Organization Against Trachoma

President: Dr. A. F. MacCallan, 33 Welbeck St., London, W., England.

FOREIGN

British Medical Association, Section on Ophthalmology

President: Dr. Stewart Duke-Elder, 59 Harley St., London, W. I.
Secretary: Dr. Thomasina Belt, 13 Mitchell Ave., Jesmond, Newcastle-on-Tyne.
Place: Plymouth. Time: July 20-22, 1938.

Chinese Ophthalmological Society of Peiping

President: Dr. H. T. Pi, Peiping Union Medical College, Peiping.
Secretary: Dr. C. K. Lin, 180 Hsi-Lo-yen, Chienmeng, Peiping.
Place: Peiping Union Medical College, Peiping. Time: Last Friday of each month.

German Ophthalmological Society

President: Prof. Lohlein, Jena.
Secretary: Prof. A. Wagenmann, Heidelberg.
Place: Heidelberg. Time: July 4-6, 1938.

Midland Ophthalmological Society

President: Dr. T. E. Ashdown Carr, 34 Charnwood St., Derby, England.
Secretary: T. Harrison Butler, 81 Edmund St., Birmingham, England.
Place: Birmingham and Midland Eye Hospital.

Ophthalmological Society of Egypt

President: Prof. Dr. Sayed Abdel Hamid Soliman Pasha, Faculty of Medicine, Cairo.
Secretary: Dr. Abdel Fattah El Tobgy, 3 Midan Soliman Pasha, Cairo.
Place: Memorial Ophthalmic Laboratory, Giza. Time: March 25, 1938.

Ophthalmological Society of the United Kingdom

President: Mr. Gordon M. Holmes, 9 Wimpole St., London, W. 1.
Secretary: Mr. J. D. M. Cardell, 27 Weymouth St., London, W. 1.

Ophthalmology Society of Bombay

President: Dr. D. D. Sathaye, 127 Girgaum Road, Bombay 4.
Secretary: Dr. H. D. Dastur, Dadar, Bombay 14.
Place: H. B. A. Free Ophthalmic Hospital, Parel, Bombay 12. Time: First Friday of every month.

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* Secretaries of societies are requested to furnish the information necessary to make this list complete and to keep it up to date.

OXFORD OPHTHALMOLOGICAL CONGRESS

Master: Dr. C. G. Russ Wood, Hill House, Abberbury Rd., Iffley, Oxford, England.
Hon. Secretary-Treasurer: Dr. F. A. Anderson, 12 St. John's Hill, Shrewsbury, England.
Time: July 7-9, 1938.

PALESTINE OPHTHALMOLOGICAL SOCIETY

President: Dr. Arieh Feigenbaum, Abyssinian Str. 15, Jerusalem.
Secretary: Dr. E. Sinai, Tel-Aviv.

POLISH OPHTHALMOLOGICAL SOCIETY

President: Dr. W. Kapuściński, 2 Waly Batorego, Poznań.
Secretary: Dr. J. Sobański, Lindley'a 4, Warsaw.
Place: Lindley'a 4, Warsaw.

ROYAL SOCIETY OF MEDICINE, SECTION OF OPHTHALMOLOGY

President: Dr. Ransom Pickard, 31 E. Southernhay, Exeter, England.
Secretary: Dr. A. Rugg-Gunn, 35 Harley St., London, W. 1.

SOCIÉTÉ FRANÇAISE D'OPHTHALMOLOGIE

Secretary: Dr. René Onfray, 6 avenue de la Motte Picquet, Paris, 7è.

SOCIETY OF SWEDISH OPHTHALMOLOGISTS

President: Prof. K. G. Ploman, Stockholm, Sweden.
Secretary: Dr. K. O. Granström, Södermalmstorg 4 III tr., Stockholm, Sö., Sweden.

TEL-AVIV OPHTHALMOLOGICAL SOCIETY

President: Dr. D. Arieh-Friedman, 96 Allenby Str., Tel-Aviv.
Secretary: Dr. Sadger Max, 9 Bialik Str., Tel-Aviv.

TSINAN OPHTHALMOLOGICAL SOCIETY

Chairman: Dr. Eugene Chan, Cheeloo University School of Medicine, Tsinan, Shantung.
Place: Cheeloo University School of Medicine. Time: Last Thursday of alternate months.

NATIONAL

AMERICAN MEDICAL ASSOCIATION, SCIENTIFIC ASSEMBLY, SECTION ON OPHTHALMOLOGY

Chairman: Dr. Parker Heath, 1553 Woodward Ave., Detroit.
Secretary: Dr. Derrick T. Vail Jr., 441 Vine St., Cincinnati.
Place: San Francisco. Time: June 13-17, 1938.

AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY, SECTION ON OPHTHALMOLOGY

President: Dr. Harry S. Gradle, 58 E. Washington St., Chicago.
Executive Secretary-Treasurer: Dr. William P. Wherry, 1500 Medical Arts Bldg., Omaha.
Place: Washington, D. C. Time: Oct. 9-14, 1938.

AMERICAN OPHTHALMOLOGICAL SOCIETY

President: Dr. Frederick H. Verhoeff, 243 Charles St., Boston.
Secretary-Treasurer: Dr. Eugene M. Blake, 303 Whitney Ave., New Haven, Conn.
Place: San Francisco. Time: June 9-11, 1938.

CANADIAN OPHTHALMOLOGICAL SOCIETY

President: Dr. W. Gordon M. Byers, 1458 Mountain St., Montrea.
Secretary-Treasurer: Dr. Alexander E. MacDonald, 421 Medical Arts Bldg., Toronto.

NATIONAL SOCIETY FOR THE PREVENTION OF BLINDNESS

President: Mr. William Fellowes Morgan, 50 W. 50th St., New York.
Secretary: Miss Regina E. Schneider, 50 W. 50th St., New York.

SECTIONAL

CENTRAL WISCONSIN SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. L. C. Gardner, 11 N. Main St., Fond du Lac.
Secretary: Dr. G. L. McCormick, 626 S. Central Ave., Marshfield.
Place: Marshfield. Time: May 1938.

NEW ENGLAND OPHTHALMOLOGICAL SOCIETY

President: Dr. Edwin B. Goodall, 101 Bay State Rd., Boston.
Secretary-Treasurer: Dr. William P. Beetham, 5 Bay State Rd., Boston.
Place: Massachusetts Eye and Ear Infirmary, 243 Charles St., Boston. Time: 8 p. m., third Tuesday of each month from November to April, inclusive.

PACIFIC COAST OTO-OPHTHALMOLOGICAL SOCIETY

President: Dr. William D. Donoher, 1930 Wilshire Blvd., Los Angeles.
Secretary-Treasurer: Dr. C. Allen Dickey, 450 Sutter St., San Francisco.
Place: Victoria, B. C. Time: June 21-24, 1938.

PUGET SOUND ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. A. W. Howe, 740 St. Helens Ave., Tacoma, Wash.
Secretary-Treasurer: Dr. Purman Dorman, 1115 Terry Ave., Seattle.
Place: Seattle or Tacoma, Wash. Time: Third Tuesday of each month, except June, July and August.

ROCK RIVER VALLEY EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Frank W. Broderick, 501 Central Trust Bldg., Sterling, Ill.
Secretary-Treasurer: Dr. Thorsten E. Blomberg, 501–7th St., Rockford, Ill.
Place: Rockford, Ill., or Janesville or Beloit, Wis. Time: Third Tuesday of each month.

SAGINAW VALLEY ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. W. K. Slack, 308 Eddy Bldg., Saginaw, Mich.
Secretary-Treasurer: Dr. Andre Cortopassi, 703 Second National Bank Bldg., Saginaw, Mich.
Place: Saginaw or Bay City, Mich. Time: Second Tuesday of each month, except July and August.

SIOUX VALLEY EYE AND EAR ACADEMY

President: Dr. J. H. Judd, 107 S. 17th St., Omaha, Neb.
Secretary-Treasurer: Dr. J. C. Decker, 515 Frances Bldg., Sioux City, Iowa.

SOUTHERN MEDICAL ASSOCIATION, SECTION ON EYE, EAR, NOSE AND THROAT

Chairman: Dr. Grady E. Clay, Medical Arts Bldg., Atlanta, Ga.
Secretary: Dr. John R. Hume, 921 Canal St., New Orleans.

SOUTHWESTERN MICHIGAN TRIOLOGICAL SOCIETY

President: Dr. John Hunter McRae, 26 Sheldon Ave., S. E., Grand Rapids, Mich.
Secretary-Treasurer: Dr. Dewey R. Heetderks, 405 Medical Arts Bldg., Grand Rapids, Mich.
Time: Third Thursday of alternate months.

WESTERN PENNSYLVANIA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. C. M. Harris, Johnstown, Pa.
Secretary-Treasurer: Dr. C. Wearne Beals, Weber Bldg., DuBois.
Place: Johnstown, Pa. Time: May 19, 1938.

STATE

Colorado Ophthalmological Society

President: A presiding officer is selected for each meeting alternately until all members have served.
Secretary: Dr. John C. Long, 324 Metropolitan Bldg., Denver.
Place: Capitol Life Bldg., Denver. Time: 7:30 p. m., third Saturday of the month, October to April, inclusive.

Connecticut State Medical Society, Section on Eye, Ear, Nose and Throat

President: Dr. Charles T. Flynn, 41 Trumbull St., New Haven.
Secretary-Treasurer: Dr. Shirley H. Baron, 309 State St., New London.
Place: New London. Time: February 1938.

Eye, Ear, Nose and Throat Club of Georgia

President: Dr. John King, Thomasville.
Secretary-Treasurer: Dr. Mason Baird, 384 Peachtree St., Atlanta.
Place: Augusta. Time: May 1938.

Indiana Academy of Ophthalmology and Oto-Laryngology

President: Dr. E. E. Holland, 51 S. 8th St., Richmond.
Secretary: Dr. Marlow W. Manion, 23 E. Ohio St., Indianapolis.
Place: Indianapolis. Time: April 6, 1938.

Iowa Academy of Ophthalmology and Oto-Laryngology

President: Dr. H. H. Lamb, American Bank Bldg., Davenport.
Secretary-Treasurer: Dr. B. M. Merkel, 604 Locust St., Des Moines.
Place: Davenport.

Louisiana-Mississippi Ophthalmological and Otolaryngological Society

President: Dr. C. A. McWilliams, G. and S. I. R. R. Bldg., Gulfport, Miss.
Secretary-Treasurer: Dr. Edley H. Jones, 1301 Washington St., Vicksburg, Miss.
Place: New Orleans. Time: Spring, 1938.

Michigan State Medical Society, Section of Ophthalmology and Otolaryngology

Chairman: Dr. F. N. Smith, Grand Rapids Clinic, Grand Rapids.
Secretary: Dr. Dewey R. Heetderks, 26 Sheldon Ave., S. E., Grand Rapids.

Minnesota Academy of Ophthalmology and Otolaryngology

President: Dr. Walter E. Camp, 1918 Medical Arts Bldg., Minneapolis.
Secretary-Treasurer: Dr. George E. McGeary, 920 Medical Arts Bldg., Minneapolis.
Time: Second Friday of each month from October to May.

Montana Academy of Oto-Ophthalmology

President: Dr. Edward S. Murphy, Northern Pacific Hospital, Missoula.
Secretary: Dr. A. W. Morse, 507 Phoenix Bldg., Butte.

New Jersey State Medical Society, Section on Ophthalmology, Otology and Rhinolaryngology

Chairman: Dr. Oram Kline, 414 Cooper St., Camden.
Secretary: Dr. James S. Shipman, 542 Cooper St., Camden.

New York State Medical Society, Eye, Ear, Nose and Throat Section

Chairman: Dr. Marvin F. Jones, 121 E. 60th St., New York.
Secretary: Dr. Algernon B. Reese, 73 E. 71st St., New York.
Time: May 10, 1938.

NORTH CAROLINA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. J. M. Lilly, 302 Old St., Fayetteville.
Secretary-Treasurer: Dr. Frank C. Smith, 106 W. 7th St., Charlotte.
Place: Charlotte. Time: October.

NORTH DAKOTA ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. H. Rosenberger, 221–5th St., Bismarck.
Secretary-Treasurer: Dr. F. L. Wicks, 514–6th St., Valley City.
Place: Bismarck. Time: May 1938.

OREGON ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. A. B. Dykman, Medical Dental Bldg., Portland.
Secretary-Treasurer: Dr. Andrew J. Browning, 418 Mayer Bldg., Portland.
Place: Good Samaritan Hospital. Time: Third Tuesday of each month.

RHODE ISLAND OPHTHALMOLOGICAL AND OTOLOGICAL SOCIETY

Acting President: Dr. N. Darrell Harvey, 112 Waterman St., Providence.
Secretary-Treasurer: Dr. Linley C. Happ, 124 Waterman St., Providence.
Place: Rhode Island Medical Library. Time: 8:30 p. m., second Thursday in October, December, February and April.

SOUTH CAROLINA SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. George Truluck, Orangeburg.
Secretary: Dr. J. W. Jervey Jr., 101 Church St., Greenville.

TENNESSEE ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. Kate Savage Zerfoss, 165–8th Ave., N., Nashville.
Secretary-Treasurer: Dr. W. D. Stinson, 805 Medical Arts Bldg., Memphis.
Place: Nashville. Time: April 12-13, 1938.

TEXAS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President: Dr. T. E. Fuller, 100 W. Board St., Texarkana, Texas.
Secretary: Dr. O. M. Marchman, 1719 Pacific Ave., Dallas.

UTAH OPHTHALMOLOGICAL SOCIETY

President: Dr. V. P. White, 143½ S. Main St., Salt Lake City.
Secretary-Treasurer: Dr. E. B. Fairbanks, Boston Bldg., Salt Lake City.
Time: Third Monday of each month.

VIRGINIA SOCIETY OF OTO-LARYNGOLOGY AND OPHTHALMOLOGY

President: Dr. M. H. Hood, 505 Washington St., Portsmouth.
Secretary-Treasurer: Dr. Charles T. St. Clair, 418 Bland St., Bluefield, W. Va.

WEST VIRGINIA STATE MEDICAL ASSOCIATION, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. George Traugh, 309 Cleveland Ave., Fairmont.
Secretary: Dr. Welch England, 621½ Market St., Parkersburg.

LOCAL

ACADEMY OF MEDICINE OF NORTHERN NEW JERSEY, SECTION ON EYE, EAR, NOSE AND THROAT

President: Dr. James A. Fisher, 501 Grand Ave., Asbury Park.
Secretary: Dr. William F. McKim, 488 Sanford Ave., Newark.
Place: 91 Lincoln Park South, Newark. Time: 8:45 p. m., second Monday of each month, October to May.

Akron Academy of Ophthalmology and Otolaryngology

President: Dr. L. E. Brown, Second National Bldg., Akron.
Secretary-Treasurer: Dr. C. R. Anderson, 106 S. Main St., Akron.
Time: First Monday in January, March, May and November.

Atlanta Eye, Ear, Nose and Throat Society

President: Dr. J. Mason Baird, Medical Arts Bldg., Atlanta, Ga.
Secretary: Dr. Alton V. Hallum, 478 Peachtree St., Atlanta, Ga.
Place: Academy of Medicine, 38 Prescott St. Time: Second Friday of each month from October to May.

Baltimore Medical Society, Section on Ophthalmology

Chairman: Dr. Henry F. Graff, 513 N. Charles St., Baltimore.
Secretary: Dr. Frank B. Walsh, Wilmer Institute, Johns Hopkins Hospital, Baltimore.
Place: Medical and Chirurgical Faculty, 1211 Cathedral St. Time: 8:30 p. m., fourth Thursday of each month from October to May.

Brooklyn Ophthalmological Society

President: Dr. Walter V. Moore, 1 Nevins St., Brooklyn.
Secretary-Treasurer: Dr. Mortimer A. Lasky, 1 Nevins St., Brooklyn.
Place: Kings County Medical Society Bldg., 1313 Bedford Ave. Time: Third Thursday in February, April, May, October and December.

Buffalo Ophthalmologic Club

President: Dr. Ivan J. Koenig, 40 North St., Buffalo.
Secretary-Treasurer: Dr. Meyer H. Riwchun, 367 Linwood Ave., Buffalo.
Time: Second Thursday of each month.

Chattanooga Society of Ophthalmology and Otolaryngology

President: Each member, in alphabetical order.
Secretary: Dr. A. H. Benz, 706 Medical Arts Bldg., Chattanooga.
Place: Mountain City Club. Time: Second Thursday of each month from September to May.

Chicago Ophthalmological Society

President: Dr. Thomas D. Allen, 122 S. Michigan Blvd., Chicago.
Secretary-Treasurer: Dr. Earle B. Fowler, 55 E. Washington St., Chicago.
Place: Medinah Michigan Avenue Club, 505 N. Michigan Ave. Time: Third Monday of each month from October to May.

Cincinnati Ophthalmic Club

Chairman: Each member, in rotation.
Secretary-Treasurer: Dr. E. R. Thomas, 819 Carew Tower, Cincinnati.
Place: Holmes Memorial Library, Cincinnati General Hospital. Time: 8:15 p. m., third Monday of each month except June, July and August.

Cleveland Academy of Medicine, Section of Ophthalmology and Otolaryngology

Chairman: Dr. Webb Chamberlin, 7405 Detroit Ave., Cleveland.
Secretary: Dr. Walter H. Rieger, Hanna Bldg., Cleveland.
Place: Winton Hotel. Time: Fourth Friday of each month.

Cleveland Ophthalmological Club

Chairman: Dr. Paul Moore, Republic Bldg., Cleveland.
Secretary: Dr. G. Leslie Miller, 14805 Detroit Ave., Cleveland.
Time: Second Tuesday in October, December, February and April.

COLLEGE OF PHYSICIANS, PHILADELPHIA, SECTION ON OPHTHALMOLOGY

Chairman: Dr. Charles R. Heed, 1205 Spruce St., Philadelphia.
Clerk: Dr. Alexander G. Fewell, 1924 Pine St., Philadelphia.
Time: Third Thursday of every month from October to April, inclusive.

COLUMBUS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

Chairman: Dr. C. E. Silbernagle, 247 E. State St., Columbus, Ohio.
Secretary-Treasurer: Dr. D. M. Johnson, 327 E. State St., Columbus, Ohio.
Place: Deshler Wallick Hotel. Time: 6 p. m., first Monday of each month.

CORPUS CHRISTI EYE, EAR, NOSE AND THROAT SOCIETY

Chairman: Dr. Edgar G. Mathis, 416 Chaparral St., Corpus Christi, Texas.
Secretary: Dr. E. King Gill, 416 Chaparral St., Corpus Christi, Texas.
Time: Second Thursday of each month from October to May.

DALLAS ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Lester H. Quinn, 4105 Live Oak, Dallas, Texas.
Secretary: Dr. J. Dudley Singleton, 1719 Pacific Ave., Dallas, Texas.
Place: Dallas Athletic Club. Time: 6:30 p. m., first Tuesday of each month from October to June. The November, January and March meetings are devoted to clinical work.

DES MOINES ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. E. G. Linn, 604 Locust St., Des Moines, Iowa.
Secretary-Treasurer: Dr. Grace Doane, 614 Bankers Trust Bldg., Des Moines, Iowa.
Time: 7:45 p. m., third Monday of every month from September to May.

DETROIT OPHTHALMOLOGICAL CLUB

Chairman: Members rotate alphabetically.
Secretary: Dr. William Fowler, 1424 Maccabee Bldg., Detroit.
Time: 6:30 p. m., first Wednesday of each month.

EASTERN NEW YORK EYE, EAR, NOSE AND THROAT ASSOCIATION

President: Dr. J. D. Carroll, 102—3d St., Troy, N. Y.
Secretary-Treasurer: Dr. Joseph L. Holohan, 330 State St., Albany.
Time: Third Wednesday in October, November, March, April, May and June.

FORT WORTH EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Van D. Rathgeber, 1012 Medical Arts Bldg., Fort Worth, Texas.
Secretary-Treasurer: Dr. Charles R. Lees, 306 W. Broadway, Fort Worth, Texas.
Place: Medical Hall, Medical Arts Bldg. Time: 7:30 p. m., first Friday of each month except July and August.

GRAND RAPIDS EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Dewey R. Heetderks, 405 Medical Arts Bldg., Grand Rapids, Mich.
Secretary-Treasurer: Dr. Robert G. Laird, 116 E. Fulton St., Grand Rapids, Mich.
Place: Various local hospitals. Time: Third Thursday of alternating months, September to May.

HOUSTON ACADEMY OF MEDICINE, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. L. Allen, 1215 Walker Ave., Houston, Texas.
Secretary: Dr. George C. Farrish, 1625 Main St., Houston, Texas.
Place: Medical Arts Bldg., Harris County Medical Society Rooms. Time: 8 p. m., second Thursday of each month from September to June.

INDIANAPOLIS OPHTHALMOLOGICAL AND OTOLARYNGOLOGICAL SOCIETY

President: Dr. C. P. Clark, 24 E. Ohio St., Indianapolis.
Secretary: Dr. Kenneth L. Craft, 23 E. Ohio St., Indianapolis.
Place: University Club. Time: 6:30 p. m., second Thursday of each month from October to May.

KANSAS CITY SOCIETY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. O. S. Gilliland, 1103 Grand Ave., Kansas City, Mo.
Secretary: Dr. John S. Knight, 1103 Grand Ave., Kansas City, Mo.
Time: Third Thursday of each month from September to May. The November, January and March meetings are devoted to clinical work.

LONG BEACH EYE, EAR, NOSE AND THROAT SOCIETY

Chairman: Dr. F. C. Hertzog, 117 E. 8th St., Long Beach, Calif.
Secretary-Treasurer: Dr. Ben K. Parks, 619 Professional Bldg., Long Beach, Calif.
Place: Professional Bldg. Time: Last Wednesday of each month from October to May.

LOS ANGELES SOCIETY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Isaac H. Jones, 1930 Wilshire Blvd., Los Angeles.
Secretary-Treasurer: Dr. John P. Lordan, 2007 Wilshire Blvd., Los Angeles.
Place: Los Angeles County Medical Association Bldg., 1925 Wilshire Blvd. Time: 6:30 p. m., fourth Monday of each month from September to May, inclusive.

LOUISVILLE EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. J. S. Bumgardner, Heyburn Bldg., Louisville, Ky.
Secretary-Treasurer: Dr. Max Bornstein, Heyburn Bldg., Louisville, Ky.
Place: Brown Hotel. Time: 6:30 p. m., second Thursday of each month from September to May, inclusive.

MEDICAL SOCIETY OF THE DISTRICT OF COLUMBIA, SECTION OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

Chairman: Dr. Earle Breeding, 1801 I St., N. W., Washington.
Secretary: Dr. Elmer Shepherd, 1606—20th St., N. W., Washington.
Place: 1718 M St., N. W. Time: 8 p. m., third Friday of each month from October to April, inclusive.

MEMPHIS SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

Chairman: Each member, in alphabetical order.
Secretary: Dr. Sam H. Sonders, Medical Arts Bldg., Memphis, Tenn.
Place: Eye Clinic of Memphis Eye, Ear, Nose and Throat Hospital. Time: 8 p. m., second Tuesday of each month.

MILWAUKEE OTO-OPHTHALMIC SOCIETY

President: Dr. Thomas A. Judge, 735 N. Water St., Milwaukee.
Secretary-Treasurer: Dr. John B. Hitz, 208 E. Wisconsin Ave., Milwaukee.
Place: University Club. Time: 6:30 p. m., second Tuesday of each month.

MINNEAPOLIS OPHTHALMOLOGICAL SOCIETY

Chairman: Each member, in alphabetical order.
Secretary: Dr. M. C. Pfunder, 645 Medical Arts Bldg., Minneapolis.
Place: Hennepin County Medical Society rooms. Time: 6:30 p. m., fourth Monday of each month, October to May, inclusive.

MONTGOMERY COUNTY MEDICAL SOCIETY

Chairman: Dr. A. G. Farmer, 1040 Fidelity Bldg., Dayton, O.
Secretary-Treasurer: Dr. Rome M. Webster, 663 Reibold Bldg., Dayton, O.
Place: Van Cleve Hotel. Time: 6:30 p. m., bimonthly, first Tuesday from October to June, inclusive.

Montreal Ophthalmological Society

President: Dr. Stuart Ramsay, 1496 Mountain St., Montreal, Canada.
Secretary: Dr. J. Rosenbaum, 1396 St. Catherine St., W., Montreal, Canada.
Time: Second Thursday of October, December, February and April.

Nashville Academy of Ophthalmology and Otolaryngology

Chairman: Dr. Guy Maness, 119–7th Ave., Nashville, Tenn.
Secretary-Treasurer: Dr. Andrew Hollabaugh, Doctors Bldg., Nashville, Tenn.
Place: St. Thomas Hospital. Time: 8 p. m., third Monday of each month from October to May.

New Orleans Ophthalmological and Otolaryngological Society

President: Dr. R. H. Fisher, Chess and Checker Club, New Orleans.
Secretary-Treasurer: Dr. H. F. Brewster, 837 Gravier St., New Orleans.
Place: Eye, Ear, Nose and Throat Hospital. Time: Third Thursday of each month from October to June.

New York Academy of Medicine, Section of Ophthalmology

Chairman: Dr. James W. White, 15 Park Ave., New York.
Secretary: Dr. Rudolf Aebli, 30 E. 40th St., New York.
Time: 8:30 p. m., third Monday of every month from October to May, inclusive.

New York Society for Clinical Ophthalmology

President: Dr. Mark J. Schoenberg, 1160 Park Ave., New York.
Secretary: Dr. Jesse Stark, 45 Park Ave., New York.
Place: Squibb Hall, 745–5th Ave. Time: 7 p. m., first Monday of each month from October to May, inclusive.

Omaha and Council Bluffs Ophthalmological and Oto-Laryngological Society

President: Dr. A. J. Young, 107 S. 17th St., Omaha.
Secretary-Treasurer: Dr. Delbert K. Judd, 1020 Medical Arts Bldg., Omaha.
Place: Omaha Club, 20th and Douglas Sts., Omaha. Time: 6 p. m., dinner; 7 p. m., program; third Wednesday of each month from October to May.

Ophthalmological Society of the University of Pittsburgh

President: Dr. W. W. Blair, 121 University Pl., Pittsburgh.
Secretary: Dr. George H. Shuman, 351–5th Ave., Pittsburgh.
Time: Second Monday in November, January, March and May.

Passaic-Bergen Ophthalmological Club

President: Dr. John S. Van Winkle, 297 Broadway, Paterson, N. J.
Secretary-Treasurer: Dr. T. A. Sanfacon, 340 Park Ave., Paterson, N. J.
Place: Paterson Eye and Ear Infirmary. Time: 9 p. m., last Friday of every month, except June, July and August.

Philadelphia County Medical Society, Eye Section

Chairman: Dr. Sidney L. Olsho, 235 S. 15th St., Philadelphia.
Secretary: Dr. Edmund B. Spaeth, 1930 Chestnut St., Philadelphia.
Time: First Thursday of each month from October to May.

Pittsburgh Ophthalmological Society

President: Dr. Glendon E. Curry, Westinghouse Bldg., Pittsburgh.
Secretary: Dr. George H. Shuman, 351–5th Ave., Pittsburgh.
Place: Pittsburgh Academy of Medicine Bldg. Time: Fourth Monday of each month, except June, July, August and September.

Richmond Ophthalmological and Oto-Laryngological Society

President: Dr. N. H. Turner, 200 E. Franklin St., Richmond, Va.
Secretary: Dr. Richard W. Vaughan, Medical Arts Bldg., Richmond, Va.
Place: Westmoreland Club. Time: 6 p. m., second Monday of each month from October to May.

ROCHESTER EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. R. E. Elliott, 78 S. Fitzhugh St., Rochester, N. Y.
Secretary-Treasurer: Dr. Raphael Farber, 280 Monroe Ave., Rochester, N. Y.
Place: Rochester Medical Association, 113 Prince St. Time: 8 p. m., third Monday of each month from October to May.

ST. LOUIS OPHTHALMIC SOCIETY

President: Dr. Lawrence T. Post, 508 N. Grand Blvd., St. Louis.
Secretary: Dr. Leslie Charles Drews, 508 N. Grand Blvd., St. Louis.
Place: Oscar Johnson Institute. Time: Clinical meeting 5:30 p. m., dinner and scientific meeting 6:30 p. m., fourth Friday of each month from October to April, inclusive, except December.

SAN ANTONIO OPHTHALMOLO-OTO-LARYNGOLOGICAL SOCIETY

President: Dr. Oscar H. Judkins, 414 Navarro St., San Antonio, Texas.
Secretary-Treasurer: Dr. Wilfred E. Muldoon, 414 Navarro St., San Antonio, Texas.
Place: Bexar County Medical Library. Time: 8 p. m., first Tuesday of each month from October to May.

SAN FRANCISCO COUNTY MEDICAL SOCIETY, SECTION ON EYE, EAR, NOSE AND THROAT

Chairman: Dr. Joseph W. Crawford, 490 Post St., San Francisco.
Secretary: Dr. Russell Fletcher, 490 Post St., San Francisco.
Place: Society's Bldg., 2180 Washington St., San Francisco. Time: Fourth Tuesday of every month except May, June, July and December.

SHREVEPORT EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. J. A. Wilkinson, Medical Arts Bldg., Shreveport, La.
Secretary-Treasurer: Dr. W. L. Atkins, 940 Margaret Pl., Shreveport, La.
Place: Shreveport Charity Hospital. Time: 7:30 p. m., first Monday of every month except July, August and September.

SPOKANE ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Raymond A. Lower, 407 Riverside Ave., Spokane, Wash.
Secretary: Dr. Louis A. Parsell, Paulsen Medical and Dental Bldg., Spokane, Wash.
Place: Paulsen Medical and Dental Library. Time: 8 p. m., fourth Tuesday of each month except June, July and August.

SYRACUSE EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Gordon D. Hoople, 110 Medical Arts Bldg., Syracuse, N. Y.
Secretary-Treasurer: Dr. I. Herbert Katz, 212 Medical Arts Bldg., Syracuse, N. Y.
Place: University Club. Time: First Tuesday of each month except June, July and August.

TORONTO ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

Chairman: Dr. Samuel Mortimer Lyon, 122 Bloor St., W., Toronto, Canada.
Time: First Monday of each month, November to April.

WASHINGTON, D. C., OPHTHALMOLOGICAL SOCIETY

President: Dr. G. Victor Simpson, 1710 Rhode Island Ave., N. W., Washington, D. C.
Secretary-Treasurer: Dr. Frank D. Costenbader, 1726 I St., Washington, D. C.
Place: Episcopal Eye, Ear and Throat Hospital. Time: 8 p. m., first Monday in November, January, March and May.